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Illuminating Engineer

XVIII. December, 1935 Price 9

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THE COILED-COIL LAMP represents the greatest advance in lamp manufacture for the past twenty years. Owing to reduction in heat losses up to 20% more light is available for the same cost and the same current consumption. Coiled-coil lamps are made by the manufacturers of the following brands of lamps:—

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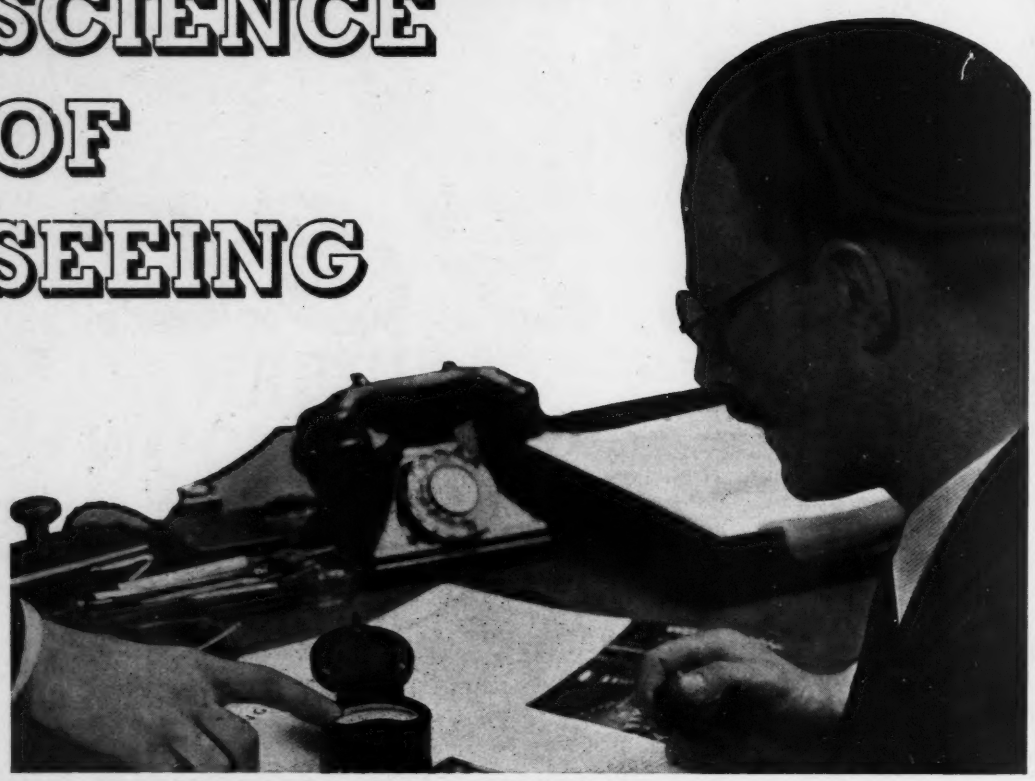

Prolonged periods of working under poor lighting conditions in offices leads to eyestrain and nervous troubles . . . . . .

Visit the E.L.M.A. Lighting Service Bureau and compare the amount of light your eyes require with the amount of light you are giving them. Means have been provided for demonstrating this new science of seeing to every type of light user, and a mass of statistical evidence has been collected on the all-important subject of the protection of eyesight.

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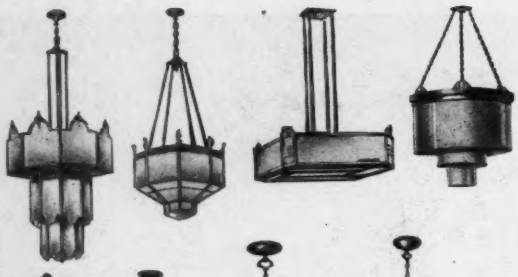

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And you pore over books, dull
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While your hope is to "sermon,"
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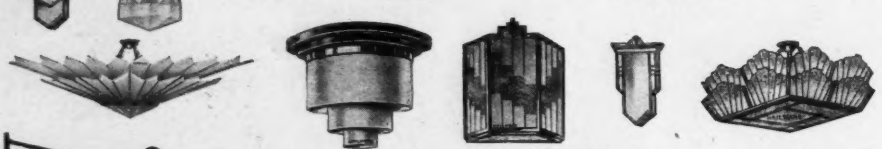

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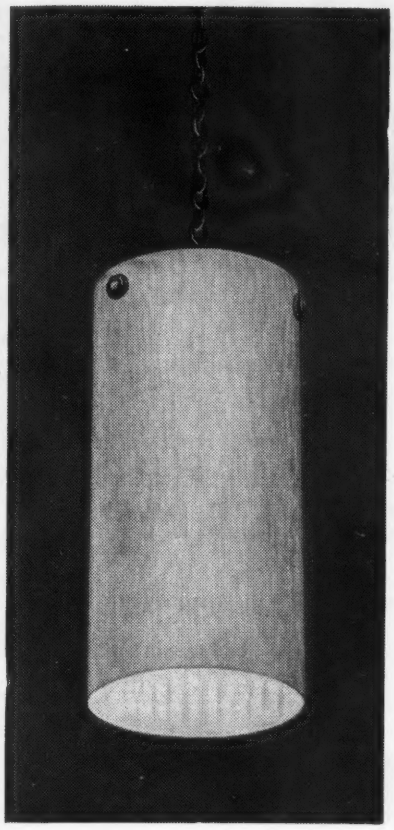

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That public taste to-day is all for SIMPLE BEAUTY is strikingly illustrated by this recent addition to the range of VITREOSIL Heat-proof Lighting Ware. Vitreosil Globe No. 564 (shown here) presents an exquisite example of modern simplicity of design combined with the artistic charm and high lighting efficiency of Vitreosil. It will pay you to stock it and offer it to your customers.

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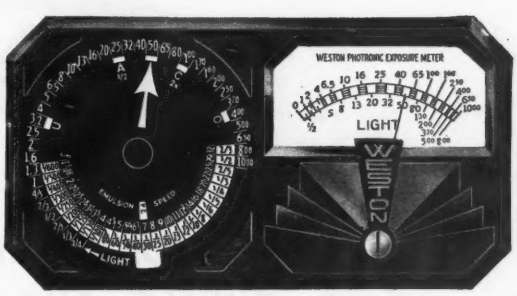
HERE is the ideal gift—to do with lighting, but requiring no power supply—the very latest model of the famous WESTON Photographic Exposure Meter.

If you happen to be a photographer, you will already know about the existing Exposure Meter, with its long-life "Photronic" photo-electric cell. If you are not a photographer, you do know the WESTON reputation over nearly half a century as makers of precision indicating instruments.



This NEW meter (available from December 2nd) retains the best features of the old meter, but gives the following improvements: SENSITIVITY more than three times greater, giving dependable results on indoor as well as outdoor subjects. EASY READING SCALE, facilitating readings of lower light values where exposure is most critical. SIMPLER EXPOSURE DIAL, re-designed for more rapid use. CONVENIENT SHAPE, easily fitting the pocket or camera case.

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REQUIRES NO CHOKE CONDENSER

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Official Journal of THE ILLUMINATING ENGINEERING SOCIETY
FOUNDED IN LONDON 1909
INCORPORATED 1930

The ILLUMINATING ENGINEER

THE JOURNAL OF GOOD LIGHTING

Edited by

J. STEWART DOW

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FOUNDED 1923
INCORPORATED 1928

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A New Departure

FOR twenty-seven years—ever since the Illuminating Engineering Society was formed in 1909—its papers and discussions have been published in full in this Journal. Undoubtedly the arrangement has answered well. Yet it had certain drawbacks.

For some time it has been evident that the work of the Society would ultimately outgrow this arrangement, and that the Society would soon attain the stage of taking complete responsibility for the publication of its own Transactions.

From the standpoint of a journal, likewise, the inclusion of such a considerable amount of technical material is not quite happy. A journal, to be of service, must appeal to masses of readers. Highly technical data, however valuable, can only appeal to experts, who are comparatively few.

The new arrangement, which will come into operation with our next issue (January, 1936), is designed to meet both these requirements.

In future papers read before the Society, and discussions thereon, will take the form of "Transactions," circulated free to all members of the Society as separate insets in the Journal. Special spring binders, enabling such Transactions to be conveniently retained in order, will be furnished free to all members who desire them. Copies of Transactions will be numbered in succession, In general, each number will deal with a particular meeting of the Society. Annual Indexes will be issued.

The Journal will continue to be circulated free to all its members, but will also have an independent circulation amongst those outside its ranks. Meetings of the Society will in future be reported in a much briefer and more popular style. The space thus set free will be available for original articles, descriptions of installations and equipment, notes and news from all quarters. In its new form, and under its new title "Light and Lighting," the Journal should appeal to a much larger circle of readers and achieve more perfectly one of the main objects of the Society—the wide dissemination of information on the nature of good lighting and its value to mankind.

Illumination and Vision

The paper on the above subject read by Dr. R. J. Lythgoe at the meeting of the Illuminating Engineering Society on November 12, together with the ensuing discussion, is to appear in the first issue of the "Transactions" of the Society, to appear in January next. For the moment it need only be said that it furnished a most interesting survey of the relation between illumination and vision—the more so because it suggested so many problems that have not yet been solved. There were present a number of physiologists and others who had special knowledge of these topics, and the discussion—an exceptionally good one—was opened by Sir John H. Parsons, who was President of the Society in its early days, and the author of the very first paper read before it, on "Glare: Its Causes and Effects."

A Forthcoming Visit

An informal visit has been arranged to take place on Tuesday, January 7, when members of the Illuminating Engineering Society are invited to assemble at 6 p.m. at the premises of the Strand Electric and Engineering Co., Ltd., at 24, Floral-street, London, W.C. A display of Modern Methods of Stage Lighting and of the New Method of Console Stage Control will be given in the demonstration theatre. Cards for this visit are not being circulated, but those who propose to take part are asked to inform the Company by letter or telephone (Temple Bar 7464), as the number that can be accommodated is necessarily limited.

Forthcoming Events.

Dec. 10. Mr. L. J. Davies on **"Practical Electric Discharge Lamps; Their General Applications and Recent Advances."** *(General Meeting of the Illuminating Engineering Society to be held at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1);* **6.30 p.m.**

Dec. 17. Mr. Ralph G. Hopkinson on **"The Photographic Representation of Street Lighting Installations"** *(Joint Meeting of the Illuminating Engineering Society and the Royal Photographic Society of Gt. Britain, in the lecture theatre of the latter at 35, Russell Square, London, W.C.1);* **6 p.m.**

1936.
Jan. 7th. Informal Visit to the **Demonstration Theatre** of the Strand Electric and Engineering Co. Ltd., at 27, Floral Street, London, W.C.; **6.0 p.m.**

An Appeal for Volunteers

The Technical Committee of the Illuminating Engineering Society, which was formed only a few years ago, is already doing excellent work. There has already become apparent, however, a definite need for helpers who are prepared to devote part of their free time to inquiries and experiments on some of the topics under consideration. As almost invariably happens in such cases, the members of the Technical Committee serve on others, and have many calls on their time. It is difficult for them to follow up inquiries in detail. There must, however, be many of the younger members of the Society who could render good service by taking on some of these inquiries, such as might ultimately furnish interesting papers for the Society. We understand that one of the investigations in view at the moment relates to the testing and measurement of gloss and polish on materials in various industries. Will any members who are prepared to help in this way, send in their names to the Honorary Secretary?

Association of Public Lighting Engineers

Mr. J. S. Dow has resigned his position as Honorary Secretary of the Association of Public Lighting Engineers, but will continue in office until the termination of the present year (1935).

Progress in Illumination

(Report prepared by the Technical Committee of the Illuminating Engineering Society: Mr. W. J. Jones *(Chairman)*, Mr. A. W. Beuttell, Mr. H. Buckley, Mr. J. G. Clark, Mr. J. S. Dow, Mr. George Herbert, Mr. Waldo Maitland, Mr. C. A. Masterman, Mr. T. E. Ritchie, Mr. E. Stroud, Mr. G. H. Wilson. *Co-opted:* Mr. Harold Bright, Dr. S. English, Mr. H. Lingard, Mr. F. C. Smith; presented at the Opening Meeting of the Society held at the E.L.M.A. Lighting Service Bureau (2, Savoy Hill, London, W.C.) at 6.30 p.m. on Tuesday, October 8th, 1935.)

This Report is devoted mainly to progress in Great Britain during the year ending August 31, 1935. In regard to the nature of progress the experience of the past year has been repeated; that is to say, there is evidence of continuous improvement in detail, whilst further developments in several of the most notable advances of recent years are again to be recorded.

Gas Lamps and Lighting Equipment.

The past year has witnessed some new developments of a general nature. Attention has been given to scientific points in connection with by-passes for gas lamps. There have been developments in connection with redirective fittings for both high pressure and low pressure lamps, especially with a view to conforming with the British Standard Specification for Street Lighting.

The original prismatic glass dish refractors developed for use with gas lamps have been extended; three sizes, respectively 6, 8, and 10 inches in diameter, and in both axial (180°) and non-axial (160°) types are now available. The intermediate size is also produced in "slotted" form for use in the square type lantern with burner and by-pass fed from underneath.

Street Lighting Performance.

Researches have been conducted by the Joint Lighting Committee of the Institution of Gas Engineers to ascertain the extent and manner in which lamps depreciate in ordinary use in streets. Full details of these researches will be included in a report to be presented at the autumn meeting of the Institution. In the meantime it is understood that the investigation indicated that gas street-lamps can be maintained under service conditions at not less than 70 per cent. of the initial or rated value; that is, the depreciation need not exceed 30 per cent.

New Type of Mantle.

On more than one occasion in the past consideration has been given to the shape of gas mantles, but general practice has been always in the direction of using a symmetrical cylindrical shape. A very definite move away from this practice is illustrated in a new form of lamp designed by the technical staff of the South Metropolitan Gas Company. The mantle in this case takes the form of a flat bag several times wider in one direction than in the other. The nozzle which produces the flame is a narrow slit instead of the usual circular orifice, the flame so produced being of a form suitable for heating the whole of the new mantle to incandescence. Naturally, the distribution of the light from this lamp is not symmetrical. The flux in the major direction is used longitudinally in the street. In addition, the lamp has prismatic glass equipment still further to redirect the flux in suitable directions. The mantle contains some novel features of construction in order to preserve its shape under the intense heat of the high pressure gas flame. The lamp was fully described in a paper read at the Annual Conference of the Association of Public Lighting Engineers by Mr. D. Chandler and Mr. A. J. Prestage, who drew attention to the improvement in the diversity ratio secured by its aid.

Special Equipment.

Other developments have been associated chiefly with the technique of gas lighting equipment for special purposes. The demand for floodlighting during the recent Jubilee celebrations resulted in several new designs, among the most notable being a unit designed to give an almost perpendicular beam. Special units have likewise been developed for the illumination of swimming pools and for schemes of architectural lighting (1). Gas table standards and floor standards for use with gas plug connectors facilitating their use in any part of the house where wall plug connections are available have also been designed.

There have been indications of a revival of interest in gas lighting in the United States. An instance is afforded by a lamp which uses low pressure gas but has embodied in it a small electric motor driving a fan which propels air and gas through the burner so as to produce a high pressure effect.

Electric Incandescent Lamps.

Coiled-coil Lamps.

Lamps with coiled-coil filaments are now available in the 60-, 75-, and 100-watt sizes, in addition to the 40-watt size first marketed. The increased light output of these lamps compared with those of single-coil construction, as furnished by lamp manufacturers, is shown in the following table:—

Increase in Efficiency of Coiled-coil Lamps Compared with Single-coil Lamps.

Lamp Size (200-250 volts)	40	60	75	100
Percentage Increase in Efficiency	20	15	12½	10

For general service such lamps replace the old single-coil type in the 40-, 60-, 75-, and 100-watt sizes. An addendum has been added to the Tungsten Filament General Service Electric Lamp Specification 161/1934, which standardises their performance and characteristics. Internally frosted bulbs are recommended therein for coiled-coil lamps in the same way

(1) Architecture Illustrated, April, 1935.

as in the specification for single-coil lamps, up to, and including, the 100-watt size.

Architectural Lamps.

Several minor improvements have been effected in these lamps during the last twelve months. In particular, coloured opal glass architectural lamps, as distinct from the colour sprayed type, have found increasing favour.

Bulbs for Miners' Lamps.

A notable forward step has been taken in the standardisation of lamp bulbs for miners' handlamps. As a result of close co-operation between the Mines Department, the manufacturers of electric handlamps and the E.L.M.A., a new and more exacting British Standard Specification for the approved types of miners' handlamp bulbs is being prepared, and will, it is hoped, be available shortly. Under the new procedure the Mines Department Testing Station will test lamps of all makers for conformity to the new specification. These lamps will then be approved and a special stamp authorised.

Electric Discharge Lamps.

Extended Use and Improved Efficiency.

The use of these lamps on public highways has increased rapidly during the past year, and much more experience of their performance in practice is available. It is estimated that at the present moment there are betwen 6,000 and 8,000 lamps of the high-pressure mercury vapour type in use in this country, and that about 200 miles of public roads are lighted in this manner. There has likewise been a steady advance in efficiency and quality. The initial efficiency of the high-pressure mercury vapour 400-watt lamp has been increased from 40 to 45 lumens per watt (an increase of 12½ per cent.), and the average output during a life of 1,500 hours from 31 to 37 lumens per watt (an increase of 20 per cent.). There have also been improvements in detail of auxiliaries, e.g., in the electrical qualities and accuracy of adjustment of choke coils and condensers, with special regard to suitability for use under conditions of overloading or in tropical climates.

Substitution of Filament for Choker.

A new development of considerable interest is the introduction of a new lamp which utilises the resistance of a tungsten filament instead of a choke coil to stabilise the discharge—thus obviating the need to introduce condensers for power-factor correction. The lamp can be inserted in any G.E.S. holder without any alterations in wiring being necessary. In addition, the use of the tungsten filament provides a considerable amount of radiation at the red end of the spectrum, and effects a substantial improvement in the colour of the light.

Advances have also been made in the design of discharge lamps yielding blue, green, and yellow light, and tubes using neon gas to furnish light of a red colour. The latter operates on a normal A.C. supply of 200-260 volts, and is controlled by a suitable choke.

Super-High-Pressure Mercury Lamps.

Another noteworthy development has been the production of a new form of water-cooled super-high-pressure mercury lamp, which consumes up to 1,500 watts per inch length of discharge, and attains a brightness as high as 260,000 candles per square inch. A feature of the light, which is approximately white in colour, is the existence of a continuous spectrum on which the mercury lines are superimposed, resulting in relatively small colour distortion. This lamp operates at 50 to 60 lumens per watt. A lamp of somewhat lower rating, functioning in air and not water-cooled, has also been produced, the efficiency in this case being about 40 lumens per watt.

Electric Lighting Accessories and Equipment.

General Lighting.

Various types of fittings intended primarily for industrial lighting have been developed. A combination of standard overhead reflector units with side-lighting by special floodlight units, equipped with a scoop-shaped vitreous enamelled reflector, and behind an aluminium reflector, of variable tilt, designed to throw the light forward, has proved useful in some large erecting sheds. In weaving sheds units comprising 60-watt lamps in vertical elliptical reflectors, have been mounted over moving parts in order to afford supplementary high intensity lighting. For use in assembly shops with low ceilings a form of lighting with striplite lamps in vitreous enamelled troughs has been developed. One new type of vitreous enamelled reflector, specially designed to get the full value of specular reflection from such surfaces, is suitable for spacing at distances equal to two and a half times the amounting height, whilst still preserving an angle of cut-off of 70°.

Special attention has recently been devoted to the development of flame-proof fittings. A bulkhead unit of this type for 100-watt lamps embodies a prismatic reflector and also a prismatic front with a view to giving a very wide light distribution. Another fitting having somewhat similar constitution, but intended for use as a pendant, and with 200-watt lamps has been introduced. Both have been tested and certified as flame-proof by the Mines Department testing station at Buxton.

Another development is a special interior lighting fitting designed to increase the intensity on the working plane without increasing the brightness at points within the normal range of vision, and without abstracting too much light from the ceiling. This diffusing glass enclosed unit has a mirrored top surface and a satin finished bottom surface. The lamp within is enclosed in a graded sprayed glass cylinder such that all rays directed towards an observer within the normal range of vision are sufficiently diffused to eliminate glare.

For use in situations where cornice lighting is desired but the headroom is limited a new enclosed diffusing trough unit, utilising two lamps up to 60-watt in capacity, has been designed. The metal back has two sides at right angles so as to fit the corner between ceiling and wall. These units can also be installed in a vertical position in the corner between two walls or can be built up into columns.

A form of square type symmetrical concentrating reflector, fitting above a flat dish, has been evolved for use in lighting shop windows. The dish carries asymmetrical prims so that, when mounted flat in a false ceiling, the light is projected downwards and inwards—an asymmetric lighting effect being thus combined with a symmetrical and pleasing appearance of the fitting.

A novel feature in connection with shop lighting equipment is the introduction of mirror-glass reflectors having glass coloured red or amber. The direct light is unaffected but the reflected light, after pas-

sage through the coloured glass on its way to and from the reflecting surface, becomes correspondingly tinted. The accentuation of certain colours in this way is found advantageous in certain shops, e.g., those devoted to the display of meat or fish.

An unusual and interesting fitting has been recently dispatched to South Africa for installation in the Pretoria City Hall. It has on overall height of 15 feet, a diameter of 12 feet, and weighs two tons. The fitting embodies both white and three-colour lighting. The total loading for white light alone exceeds 20 kw.; equivalent loading is provided in the three colours.

Mention may also be made of the effort in progress to frame a specification for a standard type of study lamp, on similar lines to that approved in the United States.

The wider application of electric discharge lamps to industrial uses has likewise led to extensions in design. Industrial units having special anti-condensation top connecting boxes and other waterproof arrangements, similar to those previously designed for 400-watt lamps are now available for high-pressure mercury vapour lamps of the 250-watt type. The range of contours of reflectors for use with these units is being extended.

Outdoor Lighting.

A feature in the design of outdoor lighting units has been the continued adaptation of lanterns to developments in electric discharge lamps. Lanterns of the rectangular type using prismatic refracting plates of new design in the main faces of the lanterns have been developed, and have been applied for use with horizontal burning sodium vapour lamps; lanterns embodying one plate on each side are used with 50- and 70-watt lamps; two plates per side are used with 100- and 150-watt lamps. The plates are of two-piece construction and have smooth exterior surfaces.

Attention has been drawn to a type of vitreous enamelled reflector for use with filament lamps in lighting roads in rural areas where wide spacing of units is usual.

The continuous development of special fields of lighting, such as the illumination of aerodromes and outdoor swimming pools has also led to the design of special units; reference is made to these in the sections below dealing with these subjects.

Domestic and Office Lighting.

No very new developments have been reported in this field. The tendencies noted in the previous report, such as the use of flashed opal glass to conceal the source and diffuse the light, and the adoption of enclosed fittings of a design reducing harbourage of dust to a minimum, continue to find favour. In view of the recognition that certain exacting tasks demand a higher illumination than can be conveniently furnished by general lighting alone, a reversion in certain types of offices to supplementary local lighting seems not unlikely—the standard of both local and general lighting being, however, very much higher than in the past.

Architectural Lighting.

Indirect lighting is still being developed in all spheres of architectural work and many ingenious arrangements have been evolved. The use of torches or floor standards as a supplement to general lighting and of combinations of direct and indirect lighting has been noticeable. Development in architectural lighting with gas lamps has proceeded steadily (*Architecture Illustrated*, April, 1935).

It is of interest to observe the application of architectural lighting methods in transport services. Indirect lighting has been introduced in recently constructed American stream-lined cars, and in other branches of transport service in the United States. In two instances in this country (the "Queen of Scots" and the "Flying Scotsman") modes of concealed lighting have been adopted.

A striking recent example of architectural lighting is afforded by the interior decoration of the new S.S. Orion, the 23,000 ton Orient Line ship for Australian service. The low ceilings afford little space for deep cornices. Special reflectors had accordingly to be designed in order to project light through the relatively small space between ceiling and cornice and to cover the ceiling surface adequately. With a cornice placed 1-20 of a span from the ceiling comparatively even illumination may be secured. With a consumption of three watts per square foot approximately 4½ foot-candles was recorded.

Industrial Lighting.

Whilst no great advance in industrial lighting has taken place there have been numerous new installations of interest and improvements in existing installations. Increased use is being made of lamps of high power, but the installation of suitably designed reflectors is still apt to be neglected with the result that glare is prevalent. In a few iron foundries substantial improvements in lighting have been noted; in several cases electric discharge lamps have been installed with satisfactory results, the illumination being raised to a value considerably above that usual in foundries. Some improvement in the lighting of steel tool cutlery and silversmiths' factories is evident, but in others conditions of lighting remain poor.

The use of local lighting, supplementing general lighting, has increased, especially for certain processes requiring exceptionally high illumination. The use of small voltage lamps in miniature reflectors in order to illuminate strongly parts of machines that cannot be easily lighted by other methods is becoming more usual, such special units being not infrequently incorporated in the design of the machine which it is desired to light.

In the annual report of the Chief Inspector of Factories reference is made to several installations in which somewhat novel methods are adopted Amongst these may be noted the use in weaving sheds of 60-watt lamps in elliptical reflectors to supplement the general lighting and the mounting of architectural striplite lamps in recesses in a low corrugated ceiling of an automobile assembly shop. Another interesting case was that of a vitreous enamelling shop in which the walls, ceiling and floor are all dead white in colour; glareless and practically shadowless lighting being secured by the use of a large number of bowl sprayed lamps.

The use of electric discharge lamps in industry is still extending and one observes an increasing tendency to make use of floodlighting effects. For example in an aircraft works this method of lighting has been applied to furnish a minimum illumination at floor level of 18 foot-candles. It has also been applied, in combination with general lighting, in some large erecting and press shops and for the illumination of large sewage disposal plants.

Several researches of considerable interest bearing on the relation between illumination and performance of work have been undertaken during the past year. These are the subject of reference under the heading "Research."

Public Lighting.

During the past year the benefits of good public lighting and the necessity for improvements have been frequently emphasised. Less has been heard of reasons for restricting street lighting in the interests

of local economy. The situation is reflected in the annual record of development presented to the Association of Public Lighting Engineers. Evidence has been given on behalf of several bodies, including this Society, before the Streetlighting Committee operating under the Ministry of Transport, whose report is awaited with interest. The concentration of attention by the Ministry on safety measures and the continual increase in the number of illuminated guardposts and refuges, and traffic signals have had some influence on lighting. Widenings and straightenings of roads have likewise involved alterations in systems of lighting and sometimes improvement.

Safety and public lighting have been closely associated during the year, notably in the paper by S. B. Langlands at the National Safety First Congress, in the presidential address delivered by C. C. Paterson to the Junior Institution of Engineers and in the discussions opened by C. A. Masterman and J. M. Waldram, before the North West Section of this Society. In some of the papers and addresses the importance of the nature of the road surface and the part played by high and uniform road brightness on visibility, was explained very fully.

Further discussion on the essentials of good public lighting took place at the Conference of the Association of Public Lighting Engineers in London during September 9-12, for example, in the analysis of modern views of street lighting and their relation to visibility contributed to by F. C. Smith and K. F. Sawyer, which also discussed the British Standard Specification. A feature was the exhibition of a film taken in the streets illustrating the importance of background. The same device was adopted in connection with a paper by R. Maxted, L. J. Davies, and G. S. Lucas, in which the importance of kinematical factors in roadway illumination was illustrated.

Costs and statistics on street lighting were treated in a paper by R. Parker and D. Chandler and A. J. Prestage described the performance of the recently introduced gas lamps with strip-mantles, mentioned previously in this report. Other papers by W. J. Allbright on developments in electric lighting in London, and by J. Adolph on public lighting in Germany, were in the nature of surveys of recent developments.

In public lighting a feature has been the extension of use of high-pressure mercury vapour electric discharge lamps, sometimes in combination with filaments in order to improve the colour of the light whilst, in addition to recent installations in London of the new gas lamps referred to above, a high-pressure installation in Birmingham up to Class A standard is reported. The standard of illumination on many of these recent installations is relatively high. The view has been frequently expressed that no road carrying any material amount of traffic should be lighted to less than Class F standard.

General questions in connection with public lighting, such as administrative methods of securing uniform treatment of arterial roads and the desirability of fully qualified public lighting engineers being appointed in cities of importance, were discussed in the presidential address delivered on this occasion by Mr. A. Maurice Bell.

Luminous Traffic Control Signals.

Preoccupation with the problem of road fatalities has doubtless stimulated the growth of installation of traffic signals, which has likewise been assisted by the understanding that a contribution of 60 per cent. towards the cost of approved installations would be forthcoming from the Ministry of Transport. The various types of signals mentioned in the last report all continued in use. Those based on vehicular traffic control have found special favour owing to their flexibility. During the past year, methods at several specially difficult spots in the Metropolis (e.g., Trafalgar-square, Piccadilly-circus, and Elephant and Castle) have been further developed, and in Marylebone alone over fifty road junctions have been equipped with a new form of progressive signal. Pedestrian signals have been added to existing signals in Trafalgar-square and are the subject of experiment in several provincial cities. The adoption of traffic control signals in the Mersey Tunnel, in order to allow for the different speed of two lanes of traffic, is of interest, and the method of lighting in this tunnel by means of lamps recessed behind panels of diffusing glass mounted flush with the recesses in the sides of the tunnel also deserves mention. Illuminated island platforms, directional signs, and bollards are also being more widely used. There is evidence of a growing recognition that no form of signal can be considered adequate unless it is adequately illuminated by night. Finally, certain sections of the Road and Traffic Act, 1934, which came into operation in October last, are not without interest to illuminating engineers, notably the clause making it compulsory for all bicycles to carry at night either a rear lamp or a red reflector and white surface at the back of the machine.

Railway Lighting.

There is little to report under this heading except that further experiments have been carried out with electric discharge lamps.

Owing to the possible risk of confusion between distant green signal lamps and the mercury vapour discharge lamp, most of the experiments have been carried out at points well away from running lines. A small installation is being tried at Fenchurch-street station, however, where colour correction is being applied by the mixture of ordinary filament lamps with gaseous discharge lamps in the same lantern, the proportion being 200 watts of ordinary gas-filled lamps and 400 watts for the gaseous discharge lamps. It is pointed out that this arrangement has the additional advantage that in the event of the gaseous discharge lamp failing to strike up or becoming defective from any reason unconnected with the supply, the lighting point is not totally extinguished.

Experiments in goods sheds have indicated that the staff who have to read labels and small print are very satisfied with the results given by this form of lighting.

On the underground railways there has been a considerable amount of new lighting installation work in connection with the modernisation of stations, but this has been substantially similar in method to that described in previous reports. One new feature, however, has been the use of architectural tubular lamps for the internal lighting of box signs; it has thus been found possible to reduce the width of double-faced box signs of six feet super from ten inches to four inches, and their appearance has been considerably improved as a result.

Aviation Lighting.

The design of aerodrome floodlights has undergone considerable development, and new types of incandescent lamps for floodlighting have been introduced. These improvements have led to a demand for better lighting, and the standards by which the performance of floodlights are specified have been raised. Whereas an illumination of 0.15 f.c. on a surface normal to the floodlight beam was formerly used in defining the area on which the illumination was adequate for landing, a value of 0.19 f.c. is now considered desirable. Eight 6-k.w. fixed floodlights, of the trough-reflector type with line filament lamps, have been installed round the boundary of Croydon Airport, and any one floodlight or group of floodlights can be switched on from the control tower, according to the direction of wind prevailing. Each of these floodlights illuminates an approximately circular area over 2,000 feet in diameter.

At Heston Airport three fixed floodlights have been installed, each unit consisting of three sphero-para-

bolic silvered glass reflectors equipped with 1,500-watt lamps of the rectangular filament type. The dispersion is about 120° and the intensity of the order of 1¼ million candles.

Various improvements in the design of lights are reported. Thus, the louvres of one 9-k.w. aerodrome landing floodlight are now removable (affording free access for cleaning), and are of vitreous enamelled iron. In connection with some aerodrome landing floodlight beacons all mirrors are now tilted about an axis parallel to the ground, and at an angle of 30° with the axis of the mirror, giving a better distribution of light. Improvements in obstruction and boundary lights, chiefly with a view to more exact colouration and greater robustness, have also taken place.

Considerable progress was made at the International Illumination Congress in Berlin towards the standardisation of aviation lights, not only as regards the types, but also in regard to methods of installation. The lights chiefly affected are aerodrome and airway obstruction lights, boundary lights, and landing direction indicators. In the field of aircraft lighting an important recommendation was made that the side navigation lamps should be designed to give a directive light distribution, the highest intensities being directed in those directions where the time for avoidance of collision is shortest. It was further recommended that the angle of the tail navigation lamp should be increased from 140° to 180°, with a view to the eventual simplification of the rules for crossing while in flight.

The colours of the lights used in aviation were also considered. As a result of experimental work it has been found that to avoid confusion with red, the colour limits of aviation orange should extend further into the yellow and less into the orange than was formerly considered necessary. This new colour has therefore been named aviation yellow, and replaces aviation orange. The limits for colour quality of aviation red, yellow, and green have provisionally been internationally agreed.

In connection with lighthouse illumination there are no noteworthy changes to record. Preliminary experiments are, however, being made in America, which may lead to the substitution of sodium electric discharge lamps for oil burners. At present the replacement of electric filament lamps is not considered probable.

Stage and Pageant Lighting.

Advances in this field have been concerned mainly with apparatus for the control of coloured light. One system intended to make it easy for a novice to produce any colour at will has been introduced, and another invention for the control of stage-lighting apparatus by means of an organ console keyboard has recently been described in the journal. Progress has been made in the introduction of non-inflammable colour filters. As instances of pageant lighting, reference may be made to the Aldershot Tattoo and to the special pageant organised during the Jubilee festivities at the Tower of London, where striking effects with three-colour lighting were obtained.

Floodlighting.

The outstanding event during the past year in this field of lighting was the series of displays arranged during the period of the celebration of King George's Silver Jubilee, which have been fully illustrated in the journal (2). The display through the country was on an unprecedented scale, and it is estimated that the total load for electric floodlighting was in the neighbourhood of 50,000 k.w.

Perhaps the most outstanding feature, as compared with previous displays, was the extended use of floodlighting in colour, which has provoked some discussion. Arrangements have been made whereby the apparatus for floodlighting certain public buildings in London shall be permanently available. Advantage was taken of these facilities during the recent conference of the Association of Public Lighting Engineers when Big Ben, the National Gallery, the Horse Guards, and St. Paul's Cathedral were again floodlit.

The Jubilee display doubtless had the effect of kindling interest in floodlighting, which tends to be adopted to an ever-increasing extent during festive periods and for commercial purposes by business premises, places of entertainment and hotels. Floodlighting of the various hotels in colour was a feature of the I.M.E.A. Conference at Bournemouth. The use of floodlighting in connection with sewage disposal plant has already been noted. An interesting overseas industrial installation has been in connection with the Iraq Pipe Line. Tubular 250 watt filament lamps in parabolic reflectors were assembled round each tank depot so as to give a fan of light over the whole surrounding ground and enable the night watchmen to observe the approach of any unauthorised person.

Floodlights have also been installed in increasing numbers in aerodromes and airports, notably those at Croydon, Liverpool, and Cardiff as well as on various air routes in the East.

Miscellaneous Installations.

It is only possible to mention briefly a few out of many varieties of recent installations. Much striking lighting has been undertaken in connection with new picture palaces and theatres. Amongst these, Citizen House, a small but exceptionally well equipped and distinctive theatre at Bath, may be mentioned. There has again been considerable development in the outdoor swimming pools, for which it is becoming usual to instal floodlighting. Numerous installations employing gas and electric lighting have been reported. It is now becoming customary to furnish underwater lighting, for which purpose special types of portable underwater projectors have been designed.

The lighting of the new building of the Royal Institute of British Architects, to which a special visit of members of the Society was paid and which presents original architectural features, utilises indirect lighting and fittings of unusual design. In designing the illumination a special effort to reveal interesting "architectural landscapes" by night has been made.

During the year special methods of artificial lighting have been introduced both in the National Gallery and the adjacent National Portrait Gallery. It is hoped that the extension of hours of opening of these galleries will enable many visitors who have no opportunity of visiting them during the day to do so after nightfall.

Photometry and Instruments.

Very many papers are still being published in connection with photometry and a number of new instruments have been described. Progress is in the main along the lines of the past few years and few important developments in principle have been recorded during the past year.

The problem of the primary standard of light has received further attention. Schmellenmeier (3) has described a sodium vapour lamp for which it is stated that the radiation is independent of the current strength over a wide range. Homès (4) has suggested a primary standard based on the use of liquid filters in connection with a black body at the melting point of gold. The liquid filters change the colour of the radiation so that it is the same as that of the more usual photometric sources.

In connection with the photometry of tungsten lamps, the development of filters isolating very narrow spectral regions in the neighbourhood of the crova wavelength by Gibson (5) and by Lyot (6), is of interest as affording a method of carrying out

(2) "Illum. Eng.", June, 1935, pp. 194-208.

(3) Schmellenmeier: Zeit, f. Phys. 93, pp. 705-725, 1935.
(4) Homès: Rev. d'opt. 13, pp. 273-279, 1934.
(5) Gibson: J.O.S.A. 25, pp. 131-135, 1935.
(6) Lyot: Comptes Rendus, 200, pp. 738-739, 1935.

photometric measurements without colour differences. König (7) has also written on the heterochromatic photometry problem and described methods of realising a precision average eye by means of coloured filters used additively or by spectral templates used with photo-electric cells. König has also described a filter which changes the colour temperature of black body radiations and maintains at the same time very closely the original black body distribution of energy in the spectrum.

Dziobek and Reeb (8) have investigated the Purkinje effect as shown in the photometry of gaseous discharge lamps compared with vacuum tungsten lamps, both by means of the flicker photometer and the equality of brightness photometer with full colour difference. Oakley (9) has described methods of visual measurement of discharge lamps for luminous output and also the use of the photoelectric cell in works' laboratories to maintain the photometric scale obtained visually. The use of a Wratten filter made a selenium rectifier cell give the same results as the visual method.

The illumination response characteristics of photoelectric cells have been studied by Preston and McDermott (10) and by Fleury (11). An alternating current bolometer has been constructed by Moon and Mills (12), and it is claimed that it should be of considerable use in photometry when combined with a filter such as Ives visibility filter.

A comprehensive review of the methods of spectrophotometry in use at the Bureau of Standards and at the National Physical Laboratory and also of a number of commercial spectro-photometers has been given by Gibson (13).

Wensel, Judd, and Roeser (14) of the Bureau of Standards, have used black bodies at the melting points of platinum, rhodium, and iridium to set up the colour temperature scale by means of gas-filled lamps. A comparison between this scale and that in use by the National Physical Laboratory has shown fairly satisfactory agreement between the scales in use at the two laboratories. Benford (15) has described the use of a series of liquid filters in colour temperature determinations.

Stiles and Crawford (16) have described a brightness difference threshold meter which enables the glare from light sources to be measured. Sandford and Waldram (17) have investigated the time characteristics of tungsten lamps used for signalling in beacons.

A new form of brightness meter for determining directly the brightness of artificially illuminated road surfaces has also been designed(18).

In regard to practical photometry, the most noteworthy development has been the more extended application of photo-electric methods. These have proved helpful in obtaining polar curves of light distribution in the testing departments of public lighting authorities and in other laboratories where much routine work is done. A type of auto-photometer specially designed for tests of street lighting(19) has been introduced. Photo-electric cells of increased sensitiveness and obeying the cosine law over a relatively wide angle of incidence are utilised. It is stated that readings to an accuracy of 0.002 footcandles can be obtained. The instrument embodies an arrangement enabling the user to apply a correction factor for the variation in colour of modern illuminants, including gas and electric incandescent lamps and mercury vapour and sodium electric discharge lamps.

(7) König: Hel. v. Phys. Acta. 7, pp. 427-453, 1934; Do. 8, pp. 211-224, 1935; A.T.M. 4, T.6. 7, 1935.
(8) Dziobek and Reeb: Phys. Zeit. 35, pp. 545-548, 1934.
(9) Oakley: Ill. Eng. 28, pp. 181-185, 1935.
(10) Preston and McDermott: Phys. Soc. Pro. 46, pp. 256-272, 1934.
(11) Fleury: Comptes Rendus, 199, pp. 195-197, 1934.
(12) Moon and Mills: Rev. Sc. Inst. 6, pp. 8-15, 1935.
(13) Gibson: J.O.S.A. 24. pp. 234-249, 1934.
(14) Wensel, Judd, and Roeser: B. of S. Jour. of Res. 12, pp. 527-536, 1934.
(15) Benford: J.O.S.A. 25, pp. 136-141, 1935.
(16) Stiles and Crawford: Jour, Sc. Inst. 12, pp. 117-185.
(17) Sandford and Waldram: Ill. Eng. 28, pp. 109-118, 1935.
(18) Ill. Eng. Feb., 1935, p. 56.
(19) Ill. Eng. Feb., 1935, p. 49; Mar., 1935, p. 90

Research.

Many items of research have already been dealt with in sections relating to specific fields of lighting. In regard to general problems, mention should be made of the work at the National Physical Laboratory on the determination of brightness difference threshold for white and coloured light in different conditions of vision. During the past year, investigations have been continued on the course of recovery of the eye after exposure to glare and the study of brightness difference threshold for coloured lights. Brightness difference threshold measurements have also been made for test objects appearing at points 5°, 10°, 24°, and 50° from the fixation point with various glare sources (20).

The glare meter has been modified to facilitate measurements at low brightness levels, and laboratory and street checks have been made.

The suggestions by A. W. Beuttell (21) for a code of illumination values based on the requirements of the visual task has prompted an investigation of the factors involved. One of these factors—size of work—has now been studied and the results are given in a joint report of the Industrial Health Research Board and the Illumination Research Committee (22). The data available make it possible for the most effective and economical value of illumination to be arrived at in terms of a ratio of the maximum rate of performance under unlimited illumination. So far only size of work has been considered, but it is intended to study other relevant factors.

In the report, tables and diagrams relating to performance, size of objects and illumination are presented. It is indicated that maximum performance when the size is reduced from 10 minutes to 1 minute may require the illumination to be increased as much as 100 times.

Another report issued by the same bodies deals with very rough work (tile pressing) (23). Even in this case the effect of illumination on efficiency was clearly evident, and it is inferred that at least 3-4 footcandles are desirable.

A third investigation under the same auspices, on the conditions of lighting required for weaving is now in progress.

Other researches, in part conducted for the Department of Scientific and Industrial Research, have been undertaken at the National Physical Laboratory on skylight illumination, the illumination of rooms with an obstructed outlook, the evaluation of glare from motor car headlight, and the lighting of cranes.

W. S. Stiles has undertaken a comparison of the revealing powers of white and coloured headlight beams in fog. The conclusion was formed that no material advantage could be secured by colouration of the beam (24).

The International Commission on Illumination.

No effort has been made to include in this report the results of investigations conducted for the International Commission on Illumination and presented at the recent sessions in Karlsruhe and Berlin. A detailed account of the proceedings will be published in volume form in due course. In the meantime a summary of it has appeared in the journal (25).

(The Technical Committee desires to acknowledge assistance derived from the following:—R. O. Ackerley, L. G. Applebee, S. H. Callow, A. Cunnington, E. L. Damant, W. S. Every, Dr. W. M. Hampton, Capt. W. J. Liberty, H. H. Long, R. P. Sayers, E. J. Stewart, and H. C. Weston.)

(20) N.P.L. Report, 1934.
(21) Illum. Eng., vol. 27, 1934, p. 5.
(22) The Relation between Illumination and Industrial Efficiency. 1. The Effect of size of work, by H. C. Weston.
(23) The effect of Lighting on Efficiency in Rough Work (Tile Pressing), by S. Adams.
(24) Illum. Eng., April, 1935, p. 125.
(25) Illum. Eng., Sept., 1935, p. 283.

Progress in Illumination

Exhibits at the Opening Meetings of the Illuminating Engineering Society, held in London on October 8th, and in Manchester on October 23rd, 1935.

At the opening meeting held in London, on October 8, a new departure was made. In view of the lengthy list of exhibits, each of which could necessarily be only very briefly described in the time available, members were invited to assemble at 4.30 p.m., and were thus afforded an introductory hour for examining the display. The meeting commenced at 5.30 p.m., and after an interval for refreshments the description of the exhibits was commenced at 6.45 p.m., terminating approximately at 8.30 p.m. Quite a number of the exhibits were also displayed at the opening meeting of the north-western local section in Manchester, on October 22.

The meeting in London was held as usual in the Lecture Theatre of the E.L.M.A. Lighting Service Bureau, which had again undergone reconstruction owing to the fire.

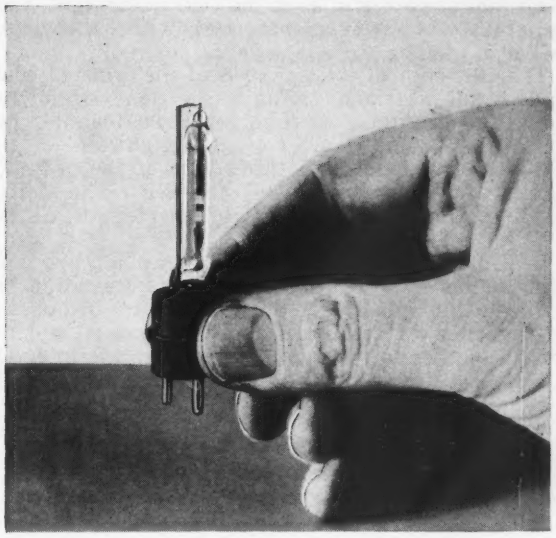
(1) The Reconstructed E.L.M.A. Lighting Service Bureau.

Mr. W. J. Jones, the opening speaker, explained that in planning the new bureau especial consideration has been given to the electrical services and ample allowance made for extensions. Circuits are subdivided and controlled in accordance with the latest practice, and the main-lighting systems for the lecture theatre, some of which total 4½ kilowatts, are controlled by push-button switches located at three different points. Two of the main-lighting installations can be dimmed down to the lowest levels of illumination by means of a special thermionic controller from miniature rheostats. In order to demonstrate the much higher levels of illumination needed for eyesight preservation no less than eighty foot-candles can be obtained over 1,400 square feet of the lecture room, while a unique frieze system of lighting in which the conduit is featured as a decorative motif provides ideal illumination for lecture purposes.

The lighting systems grouped above enable methods of industrial and commercial lighting to be demonstrated on full scale, while at the stage end the well-known demonstrations dealing with lighting principles, such as glare, speed of vision, shadows, etc., are built into the back wall so as to be immediately available at the appropriate time during the course of a lecture. Decorative lighting is also included over the stage itself, and a new type of mobile colour display with continually operating dimmers is also available for those audiences interested in the more decorative aspects of the lighting problem.

In the special-subjects studio is to be found a co-ordinated display of street, industrial, and flood-lighting equipment, and a section for home-lighting ideas. Electric discharge lamps figure prominently in this room, especially in their application for street lighting, and those visiting the bureau have at their disposal a comprehensive range of these fittings which may be closely inspected and compared.

The home-lighting section is not intended to be comprehensive, that is to say, does not include a suite of rooms with comparative systems of lighting. It merely indicates high spots in the home-lighting story, and thus completely avoids the all-too-frequent fault of becoming a furniture display.



This picture illustrates the small dimensions of the remarkable new super-pressure mercury vapour lamp shown by Professor G. B. Van de Werfhorst.

(2) A Super High Pressure Mercury Discharge Lamp.

Another new departure introduced at the meeting in London was the grouping of items, those of special novelty being taken first and others arranged roughly in classes entitled Street Lighting Equipment, Photometry, and Miscellaneous Fittings, etc.

The second item was initiated by Mr. R. P. Sayers (Philips Lamps, Ltd.), who introduced Professor G. B. Van de Werfhorst who had come over from Holland specially to make this demonstration. The new lamp utilises a quartz tube with thick walls having an internal diameter of about 5-64 in. and an external diameter of ¼ in. This little tube has an electrode at each end consisting of a simple tungsten wire sealed into the quartz with an interposed layer of special glass (to avoid too great disparity in co-efficients of thermal expansion). The electrode tips are coated with a deposit of alkaline earth oxides to facilitate the emission of electrons necessary to start a discharge and each projects from a small drop of condensed mercury. The lamp is thus of very simple nature. In its most efficient form it is placed inside a jacket containing running water.

The lamp functions on alternating current and in common with other electric discharge lamps requires a stabilising device. This is effected by feeding the lamp from an auto-transformer the self induction of which stabilises the discharge, whilst the "no load" voltage suffices to strike the lamp. The potential gradient may attain a value as high as 2,250 volts per inch, but at present about 1,250 volts per inch is the highest that the lamp will withstand, without the internal pressure becoming unduly high. The lamp then consumes about 1,500 watts per inch. The current is approximately 1.35 amps, and the power factor 0.9.

An interesting result of the very high internal pressure, which at the practical potential gradient mentioned above attains about 2,000 lb. per sq. in., is its influence on the light yielded. The spectrum is a continuous band on which the mercury lines stand out. The red rays are thus represented so that the light is approximately white in character and there is relatively little colour distortion. With the unscreened tube the radiation in the ultra violet (between 0.3 μ and 0.4 μ) is estimated to be relatively

five times as powerful as in the case of sunlight; such radiation is, however, absorbed when the water jacket is used.

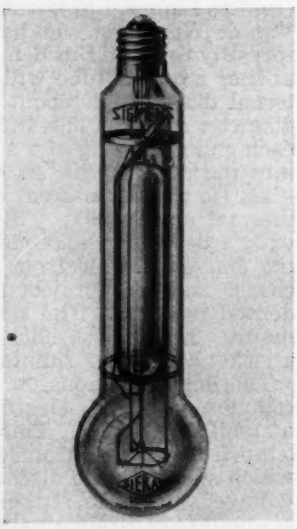
The efficiency of the source is of the order of 50-60 lumens per watt and, owing to the small size of the source, a brightness as high as 260,000 candles per sq. in. (about one quarter of the brightness of the sun and two and a half times that of the ordinary carbon arc crater) can be attained. The actual candle-power is proportional to the length of the tube.

In addition to the water-cooled lamp another type, functioning in air and of somewhat lower rating has been developed. This requires 70 watts to operate. The efficiency is about 40 lumens per watt, and the length of the discharge § in. This lamp is intended for general lighting purposes. The light is somewhat less rich in red rays, but the deficiency, it is suggested, can be corrected by using a reflector painted with "Signalon," a fluorescent red paint.

The fact that the lamp provides what is almost a point source of such great brilliancy, should render it of great service for projection purposes. An interesting application of the fact that the lamp, being fed by alternating current, is extinguished twice per cycle has been made. Apparently this renders it possible to eliminate revolving shutters on cinematograph projectors, the movement of the film and the extinctions of the lamp being suitably synchronised. As a result the screen illumination is increased by 100 per cent. For this particular application the presence of the cooling water is an advantage, owing to the absorption of heat from the source, which enables the size of the housing for the projector to be considerably reduced.

(3) "Sieray-Dual" Electric Discharge Lamps.

Mr. C. R. Bicknell (Siemens Electric Lamps and Supplies, Ltd.) demonstrated the new Sieray-Dual electric discharge lamp, which comprises an electric discharge tube and a tungsten filament arranged in series within a single outer glass bulb. The tungsten filament serves to stabilise the arc of the discharge and replaces the choke coil commonly used. At the same time it adds its contribution of red rays to the light from the discharge tube, so that the resultant light is of quite a pleasing colour. The provision of an auxiliary filament in series with the main filament obviates undue overloading when the lamp is switched on. The auxiliary filament is automatically removed from circuit by means of a thermal cut-out at a predetermined time in the run-up characteristic of the discharge tube. The power factor of the lamp is approximately 0.95, and therefore no condenser is necessary. The lamp is at present made only in the 500-watt size. It gives a total candlepower approximately 70 per cent. higher than that of an incandescent gas-filled (filament) lamp of similar wattage.



(4) Colour Floodlighting.

Mr. Bicknell also showed a Sieray tube producing a luminous column of red light about twenty-four inches long. This tube consumes 200 watts. The only auxiliary appliances needed are the standard choke coil, transformer (to supply L.T. current to the filament heater), resistance, and p.f. rectification condenser of 25 m.f.d. A floodlighting unit to accommodate such units, which provides accommodation for control auxiliaries, was also on view. This unit is mounted in a cradle for ground mounting, and is finished in aluminium cellulose. The beam spread is approximately 140 degrees in the horizontal, and 20 degrees in the vertical plane. A series of floodlighting tubes yielding green, blue, and primrose light were shown. These resemble standard electric discharge lamps, but can be burned in any position without the use of magnetic deflection devices. Floodlighting units designed to accommodate such lamps in a horizontal position, and utilising a reflector of parabolic section built up in strips of mirror glass were also shown. Adjustment for focusing is provided, and the unit is complete with watertight plug and socket for easy connection. The beam spread is approximately 90 degrees in the horizontal and 40 degrees in the vertical plane.

(5) "Supervia" Gas Lamps

Mr. A. J. Prestage (the South Metropolitan Gas Company) exhibited the new "Supervia" high-pressure and low-pressure gas lamps for highway lighting.*

A general view of the new "Supervia" H.P. Lamp, showing special slot burner and rectangular mantle.

The tent, reflector, and globe of the high-pressure lamps are of a conventional design, but the unit is provided with a special heat-resisting steel superheater containing the rectangular nozzle of dimensions 1-16 in. by 4 in. The mantle, also rectangular in shape, is carried on a frame which clamps to the superheater by two wing nuts. A rigid, chromium-plated cage carries a refracting dish of axial distribution for central suspension systems or of non-axial distribution (160 degrees) for side-mounting. With a gas rate of 0.11 therms/hour at 81 degrees w.g. pressure a maximum intensity of nearly 4,000 C.P. is obtainable in the main beams at a vertical angle of 75 degrees.

The "G" type low-pressure unit again has a tent, reflector, and globe on accustomed lines, but it has a refractory nozzle accommodating a rectangular mantle. With a dish refractor the main beam inten-

*A fully illustrated description of these lamps will be found in the paper recently read by Mr. Dean Chandler and Mr. A. J. Prestage, before the Association of Public Lighting Engineers. ("Illum. Eng.", October, 1935, pp. 315-326.)

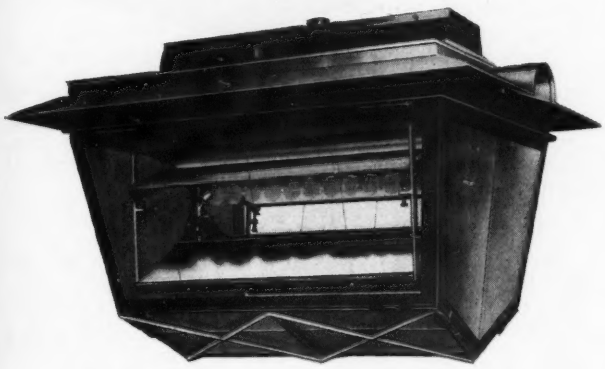
sity is about 325 C.P. on a gas rate of 0.02 therms/hour.

The "Supervia E" lamp is rectangular in shape and houses five rectangular nozzles and mantles in linear formation. The lower sections of the lantern are built up of refracting glass plates to bring the maximum intensity to 75 degrees, at which angle it reaches about 1,700 C.P. The gas rate is 0.11 therms/hour.

The construction of the "Supervia" lamps has been carried out in as simple a manner as possible. They are designed essentially to give the directional distribution required by the shape of the road surface.

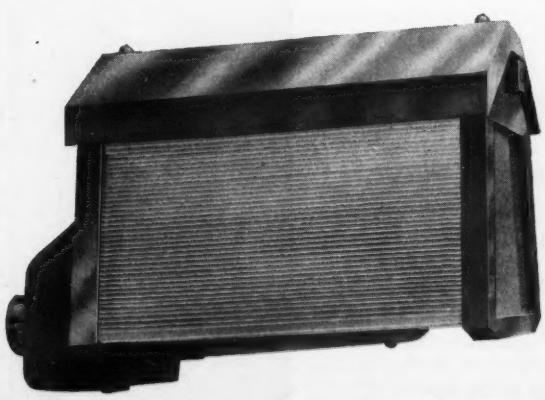
(6) New Type of Gas Lamp for Street Lighting.

Mr. A. R. McGIBBON (Wm. Sugg and Co., Ltd.) also showed a gas lamp of recent design. The lamp exhibited was the new low-pressure gas "London" street lighting lamp, fitted with streamline flow superheater carrying twelve No. 2 mantles in alignment. Special mirror trough reflectors with heat resisting backing are employed to give a wide distribution up and down the road. A maximum candlepower of about 3,000 is furnished by this lamp.



The "London" street lighting gas lamp.

In order to deal with various spacings, mounting heights, and road contours, the reflectors are independently adjustable on either side of the lamp. Knurled knobs are provided on top of the lamp for this purpose. It is thus possible to raise the main beam to produce high road brightness, or it may be lowered for mid-span illumination. An intermediate reflector, easily removable for remantling and cleaning, redirects the flux (which would otherwise be wasted above the horizontal) on to the road surface. The "Venturi" type flue not only considerably reduces the over-all height of the lamps, but ensures steady burning under the most adverse weather conditions. The burner incorporates a novel air control resulting in a very efficient light output. These lamps are made in six, eight, ten, and twelve-light sizes. The lamp exhibited was fitted with the Horstmann's "Comet" igniter.



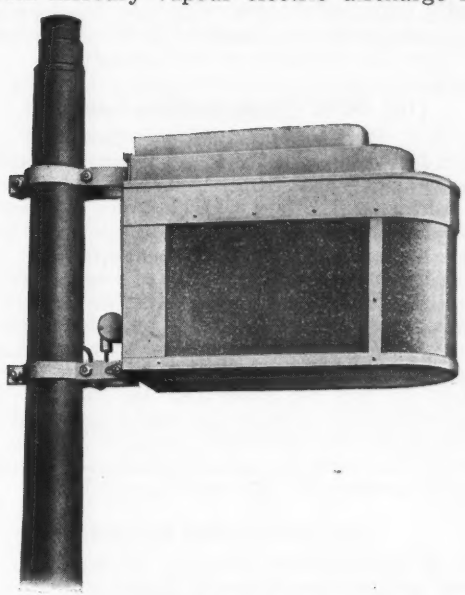
Holophane Lantern for use with horizontal burning lamps.

(7) Prismatic Panel Lanterns For Use With Horizontal Burning Sodium Lamps.

Dr. S. ENGLISH (Holophane, Ltd.) demonstrated a form of refractor lantern designed for use with horizontal burning sodium vapour lamps. This consists essentially of two double refracting prismatic panels, which are arranged to lie parallel with the lamp, one on each side of it, and at such a height as to control a large proportion of the light flux that is emitted at and above the horizontal. Each consists of two prismatic plates cemented together with their prism faces enclosed, with smooth faces on each exposed side, thus keeping the prismatic surface free from dust and dirt and rendering maintenance easy. The panels are carried in a light cast frame which also houses a reflector secured above the level of the plates and diverting its light into useful directions. The lantern as here shown accommodates 50- and 70-watt lamps, while a larger lantern carrying two prismatic panels on each side is suitable for use with 100-and 150-watt lamps.

(8) A New Street Lantern for Electric Discharge Lamps.

Mr. E. W. HARMER (Edison Swan Electric Co., Ltd.), exhibited the new "Southbury" lantern designed for use with mercury vapour electric discharge lamps primarily, but also applicable to filament lamps if desired. A feature is the use of a new reflector system of centre light control enabling a peak c.p. of the order of 8,000 to be furnished between 70 and 75. Disability glare is, however, guarded against by reduction in the candlepower in the critical angles of 80 to 90. The optical system consists of a special reflector surrounding the lamp and directing the greater part of the light on to two reflectors which divide the beam and redirect it up and down the road. The top reflector is adjustable, enabling the horizontal angle of the beam to be varied when there are bends in the road, and the angular setting of the secondary reflectors can be modified according to the spacing or gradient.



The "Southbury" Lantern.

A form of street-lighting lantern designed for use with electric discharge lamps and equipped with Holophane refractor panels, with a stainless steel reflector in the top of the lantern, was also shown by Siemens Electric Lamps and Supplies, Ltd.

(9) A Unit for Rural Roadways.

Mr. H. MUNNS (Benjamin Electric, Ltd.), showed a new vitreous enamelled reflector, the "Rural Roda-

The adjacent two street lighting lanterns for Osira Lamps were shown by Mr. J. G. Christopher (G.E.C). On the *left* is the opal diffusing type ; on the *right* the familiar refractor variety.

lux," which is specially designed for use on rural roads and, in fact, in situations where the inverted cone type of unit would formerly have been installed. He pointed out that the distribution is specially arranged for the wide spacing usually met with in such cases and designed to direct light mainly away from the footpath on to the roadway.

(10) Other Street-lighting Lanterns.

Mr. J. G. CHRISTOPHER (General Electric Co., Ltd) exhibited several types of street-lighting lanterns for Osira Lamps. These fulfilled various conditions. The Opal Diffusing Lantern, which gives general symmetric distribution, is regarded as specially suitable for use at road junctions and is equipped with a special top connecting box to prevent leakage of water into the lantern or troublesome condensation. Another type, the "Lambeth" lantern, is equipped with a single piece refractor Di-Fuser, and has now been modified to take tungsten filament lamps in addition to electric discharge lamps—the former being sometimes adopted for half-night lighting. A third type was the Birchfield refractor lantern, which embodies the familiar refractor-diffuser in combination with a specially decorative body-design.

(11) Illuminated Bollards.

Mr. E. L. DAMANT (General Electric Co., Ltd.) showed several new types of illuminated bollards of the one-way and four-way types, which conform to the Ministry of Transport recommendations. The latter are provided with four panels for "Keep Left" and similar signs. Two Pearl lamps, either 40 or 60 watt, suffice to illuminate the entire area of the device. One accessory, an example of judicious foresight, serves to prevent unauthorised removal of lamps!

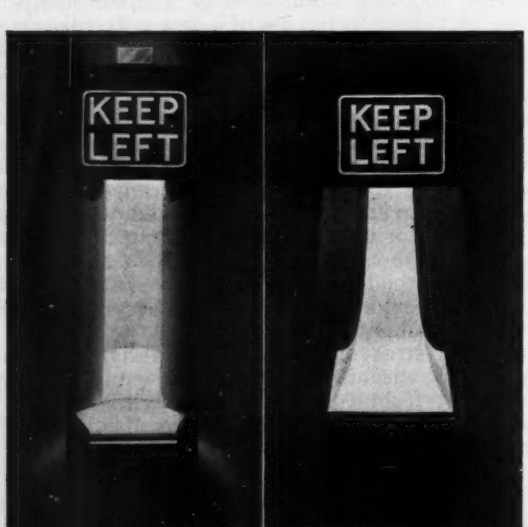
(11a) Aerodrome Boundary Light.

Mr. E. L. DAMANT was also responsible for the exhibition of an improved aerodrome boundary light, illustrated below. This, besides giving the necessary amber indication at all elevations, is provided with a stem of special contour which is floodlit in amber. This additional element enables a pilot to judge his position relative to the aerodrome boundary. Special low voltage lamps and individual isolating transformers ensure safety; if the fitting is struck by an aircraft the curved floodlit surface promptly collapses.

(12) An Apparatus to Determine the Lower Limit of Natural Illumination Tolerable for Clerical Work.

This apparatus, described by Mr. H. L. MCDERMOTT (National Physical Laboratory), was devised for carrying out an investigation, undertaken at the request of the Illumination Research Committee, to determine the value of daylight illumination at the instant when its insufficiency became so noticeable to the occupant of a desk that the artificial light was switched on.

The method employed consisted primarily in photographing a microammeter, connected to a photo-electric cell, the motive force for working the camera



The illuminated traffic bollards shown on the *left* were exhibited by Mr. E. L. Damant (G.E.C.), who also described the effective aviation boundary light which appears in the *right* hand illustration.

being derived from the current in the lamp circuit when the worker first switched on the desk light; then by a calibration of the cell and microammeter in terms of the illumination falling on the desk, it was possible to determine the value to which the illumination had fallen before the subject working at the desk made use of the desk light. The camera is a 9.5 mm. ciné camera with an f/1.9 lens with micrometer adjustment for focussing, and capable of taking single exposures. The microammeter is viewed by means of the mirror inclined at an angle of 45°; from this mirror a portion of the silvering has been removed, so as to enable a small watch suspended behind the mirror to be seen by the camera.

The part of the apparatus by which the camera is made to function is designed for use with six separate lighting circuits. Each coil is connected in series with its respective desk light, and when the lamp current is made to flow the plunger suspended inside the coil is given a downward impulse, which, owing to the fact that the initial current through a tungsten filament lamp is roughly ten times the final current, is sufficient to carry it beyond its final position of rest. In its downward travel. the plunger is made to impinge on a phosphor-bronze strip, which is depressed sufficiently by the impact to connect momentarily with a similar strip, thus completing a circuit through a 100W lamp and the actuating coil of the camera. Only one actuating circuit is necessary, as the six pairs of strips are connected in parallel.

By these means an exposure can be made whenever an office light is switched on, and the camera and actuating gear is automatically reset in readiness for the next occasion on which a lamp is switched on.

To the end of each upper phosphor-bronze strip is attached a stiff wire, terminating in a small square plate bearing a number corresponding to the strip to which it is connected. These plates are so placed that when in focus they are seen by the camera just below the edge of the mirror. At the instant when each photograph is taken the appropriate plate is displaced from its normal position, and so indicates which desk light is being used.

In most offices there are one or more main lights and, as these give a definite contribution to the illumination on each desk, it is of importance to know whether these lights are switched on. The 10W lamps are connected in parallel with each office light and are mounted behind a translucent numbered screen. The date is also indicated to complete the necessary information.

(13) Auto-Photometers for Street-Lighting Measurements.

Dr. S. English (Holophane, Ltd.) explained that these Auto-Photometers have been specially designed for street-lighting measurements; the special requirements of this type of work having been kept prominently in mind throughout the development stage, with the result that they embody several features of interest that are not found in other instruments. For example:—

(a) The light sensitive surface is specially treated so as to overcome surface reflections and thus conform to the cosine law, even to fairly wide angles of incidence. With light incident at as wide an angle as 65° the falling away from the cosine law is only about 3 or 4 per cent. At wider angles a small correction factor may be employed, or the surface may be tilted until the light is incident along the normal and horizontal readings calculated.

(b) Ordinarily, three or four scales are provided, the full scale ranges being 0.3, 3.0, 30 foot-candles in each case, with an additional range of 150 foot-candles in the four-range instrument. On the lowest scale the first graduation corresponds to 0.005 foot-candles and,

Showing general appearance of Auto-Photometer.

as it is easily possible to read in between the graduations, readings can be taken to 0.002 foot-candles.

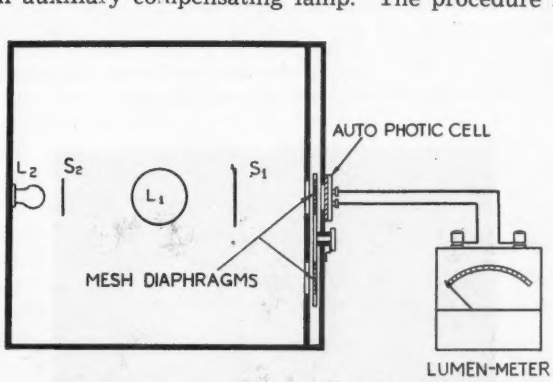
(c) The Auto-Photometers are calibrated to give direct foot-candle readings with electric filament lamps, mercury and sodium discharge lamps, and also with gas illumination. By turning a switch to the appropriate stop the corrections to the readings which are necessary when measuring these different coloured lights are made inside the instrument.

(14) A New Integrating Photometer Compensated for Obscuration.

Lt.-Col. Kenelm Edgcumbe described the latest Everett-Edgcumbe "Cube" Photometer, in which errors due to obscuration by the lamps under test are eliminated.*.

Integrating Photometers compensated by this method are not subject to the limitations as regards dimensions which are essential with the uncompensated type. (It may be mentioned that B.S.S. 345 limits the over-all length of the lamp under test to $\frac{1}{4.5}$ of the length of the side of the Integrating Cube.)

The accompanying figure shows the instrument in section. L_1 represents the lamp under test and L_2 an auxiliary compensating lamp. The procedure is



Showing essential features of Total Flux Photometer.

to apply a fixed voltage to the terminals of the lamp L_2 and to note the reading on the lumen-meter, firstly, with the standard lamp at L_1 and, secondly, with the lamp or fitting to be tested at L_1, both these lamps being "out." The ratio of these two readings represents the correction to be applied to the measurements, which are otherwise made in the usual way.

By this means bare lamps up to 500 watts can be accurately tested in a 28-inch Cube, as can also fittings up to 16 inches, or even more in diameter, as compared with a bare lamp of, say, 150 watts, which is about the limit with an uncompensated Cube of the same size.

* For further details see the "Illuminating Engineer," September, 1935, page 296.

(15) A Street Surface Brightness Meter.

Mr. A. G. BROWN (General Electric Co., Ltd.) described a new type of brightness meter which enables a direct reading to be taken of street surface

A general view of the brightness meter.

brightness. The instrument is very simple in operation. Three scales are provided to suit widely differing degrees of brightness, and a special blue filter is included to facilitate readings in streets illuminated by high pressure mercury vapour lamps. In view of the importance now attached to street surface brightness as an element in visibility this instrument should prove a very useful one.

(16) A Chart to facilitate Photometric Calculations.

The final item in the section devoted to photometry and kindred subjects was an ingenious chart exhibited by Mr. W. J. G. DAVEY (W. Parkinson and Co.). By means of a detached scale, used in conjunction with the main diagram, the illumination corresponding to any candlepower with a specified height and angle of inclination from a source can be calculated. The device should prove very helpful to engineers concerned with street lighting.

Showing the application of the instrument to the study of brightness of an actual roadway.

(17) A New Tungsten Filament Photographic Lamp.

Mr. A. G. PENNY (General Electric Co., Ltd.) showed a new photographic lamp developed by his company and Kodak, Ltd., which enabled snapshots to be taken by the ordinary photographer very easily and inexpensively. The lamp consists of a tungsten filament in a pearl bulb giving a light-output of 9,000 lumens and having a consumption of 275 watts, the efficiency being 33 lumens per watt. The effective life is equivalent to 300 snapshots. In the course of the meeting a photograph of the President and Hon. Secretary was taken by the aid of two such lamps mounted in simple reflectors, with an ordinary camera and with exposure of 1-25th sec. and an aperture of + 6.3. This photograph was taken by a representative of the technical department of Kodak, Ltd., who, in the course of thirty minutes, developed and produced a lantern slide which was demonstrated to the audience. A reproduction of the photograph is appended.

A snapshot of the President *(right)*, and the Hon. Secretary *(left)*, taken during the meeting by the aid of the new Tungsten Filament Photographic Lamp described above.

(18) An Example of Resourcefulness in Floodlighting in S. Africa.

Mr. L. E. BUCKELL (General Electric Co., Ltd.) showed several lantern slides illustrating the floodlighting of the important Government buildings in Salisbury, Southern Rhodesia. These buildings were floodlighted by Mr. W. H. Mumford, the Electrical Engineer to the Public Works Department of Southern Rhodesia on the occasion of the celebrations of the Silver Jubilee of King George V. in May last. Mr. Mumford was called upon to floodlight the buildings at short notice. He had no floodlighting equipment in his possession, and owing to the great distance between Salisbury and any suitable depots, was unable to purchase such equipment before the required date. He therefore utilised a number of empty petrol tins, one of which was shown by Mr. Buckell to the audience. The tins were cut away and a 200 watt Osram lamp installed in each. Mr. Mumford thus contrived a sufficient number of floodlighting fittings to do the job. As the lantern slides showed the result, if not equal to that attainable with scientifically designed apparatus, was quite good. This resourcefulness, Mr. Buckell remarked, was typical of our overseas engineers, and showed their adaptability and their ability to make the best of the difficult circumstances under which they often had to labour.

(19) Electric Discharge Lamps for Laboratory Use.

Mr. A. G. PENNY also showed some interesting forms of small electric discharge lamps for experimental use. He pointed out that many physical and chemical laboratories require the use of a source giving a line spectrum and furnishing known wavelengths of light for calibration purposes, from which single lines can be isolated for work requiring monochromatic radiation. His company had accordingly produced a range of small lamps to yield spectra of sodium, zinc, cadmium, mercury, and cadmium and mercury combined. The light output from these lamps is perfectly steady and of high intrinsic brightness—that of the sodium lamps, for instance, being nearly thirty times as great as is furnished by sources hitherto available. The lamps are made to operate either on ordinary D.C. or A.C., and are controlled by a series resistance limiting the current to 1.3 amps. for the sodium lamps and 2 amps. for the other types. Mr. Penny demonstrated the use of a sodium lamp in conjunction with a special holder designed by Bellingham and Stanley for their high accuracy, critical angle refractometer—which is capable of an accuracy of two parts in 100,000 when used with this light source. A cadmium lamp, of the type suitable for spectro-photometers, was also exhibited.

(20) Coloured Electric Discharge Tubes.

Captain C. HIGGINS (Claude-General Neon Lights, Ltd.) arranged a demonstration to illustrate the special advantages of the "Cleora" tubes over the cold cathode luminous discharge tubes commonly used for Neon signs, namely, the very large range of colours and the great increase in luminous efficiency obtained.

These tubes are coated internally with phosphorescent substances, in such a manner that the ultra-violet emanations from the discharge are converted into light in the visible part of the spectrum. The demonstration panel, on which the various tubes are displayed in a sunburst design, showed a range of seventeen different colours thus secured.

To show clearly the increase in luminous efficiency, Captain Higgins also showed a single tube one-half of which was coated with a phosphorescent substance and the other half left clear. He pointed out that no photometer was necessary to determine that the luminosity of the green half of this tube greatly exceeded the luminosity of the blue half (the part of the tube left clear).

(21) Apparatus for Exhibiting Biological Specimens In Glass Tanks.

Mr. HAROLD BRIGHT, in demonstrating this apparatus explained that it consists of a box having a glass top on which are placed the glass tanks containing the specimens to be viewed. An arrangement of six hinged metal flaps enables tanks of sixteen sizes to be accommodated. The illuminant is a 60-watt tubular lamp, and an optical system consisting of mirrored louvres is provided in order that a powerful upward component of illumination can be obtained without the light source being visible to the observer.

(22) Handlamp for Use in Hospitals.

Mr. BRIGHT also exhibited a handlamp intended for use with low-voltage bulbs operated from a double-wound transformer. A chromium-plated reflector of relatively high efficiency is provided, enabling low-wattage lamps to be used. The handle is arranged at the side of the reflector so that the lamp can be used for inspection work at close quarters.

A typical form of small electric discharge lamp for laboratory use.

(23) Intensive Local Lights Incorporated in Machinery.

Mr. E. W. MURRAY (Home Office Industrial Museum) explained that whilst industry had found modern methods of general illumination a valuable improvement over the original local lighting, it was now finding that conditions were still further improved when both methods were used. Local lighting in itself was not new. In the Chief Inspector of Factories' annual reports of twenty years ago, mention was made of the use of small lamps fed from secondary batteries for illuminating the dark working areas of machines. Now that A.C. supply is so usual, small transformers provided a ready means of obtaining this low voltage. The lamps used are generally of the 12-volt "omnibus" type, with a small reflector no larger than an egg-cup, and the size of the light unit makes it possible to place the light between the operator and his work, thus avoiding glare and reflected glare.

The construction of many machines, Mr. Murray pointed out, is such that even with good natural light there is some difficulty in seeing the working area clearly, but these small units can be placed quite near to the working point, often within the machine guarding, without obstructing the operator's view in any way. Important points to be remembered are that transformers should be double wound, and that the iron core should be earthed and one of the secondary terminals also earthed, in order to minimise the risk of electric shock. This method of illuminating the actual working point can be applied with advantage to almost every machine process. Mr. Murray showed a series of slides illustrating its use with band saws, drilling machines, grinders, etc.

(24) Diffusing Fittings and Reflectors with Coloured Surfaces.

Mr. S. ANDERSON (General Electric Co., Ltd.) remarked that the number of types of enclosed diffusing fitting already on the market was very large, but the new design he exhibited incorporated certain features of a novel character. The globe is made in internally frosted glass with the exception of an annular ring near the lip, which is silvered outside and unfrosted. This mirrored portion serves to redirect downwards some of the light emitted from the lamp above the horizontal, while the outer frosted ring on the upper side of the globe gives sufficient upward light to avoid a dark ceiling. Inside the globe an open glass cylinder surrounds the lamp. The lower portion of this is flashed opal, while the upper part (transmitting light to the mirror ring on the globe) is lightly frosted. The canopy is designed with a view to reducing the temperature at the top of the lampholder as far as possible. Its construction is very open, and the three copper discs divert connection currents away from the leads. In addition, the two upper discs are in intimate contact with the shell of the lampholder, thus serving to dissipate heat from the latter. The temperature at the top of the lampholder in this fitting is found to be some 25°C lower than that in a fitting of normal design with the same size of lamp. The luminous efficiency is of the order of 70 per cent., and a larger proportion of downward light is obtained than is normally provided by enclosed diffusing units. The distribution is such that spacing to mounting height ratios up to 1¼ to 1 may be employed with satisfactory results.

Mr. ANDERSON also showed some silvered glass shop-window type reflectors; amber and ruby coloured glass is employed. The controlled light is thus coloured and serves to tint the illumination provided without so large a loss as is entailed in the use of colour screens. The reflectors are intended for use in displaying certain merchandise such as fish, meat, and polished furniture, where tinted illumination is found to give an enriched appearance.

(25) A Light-Vision Demonstrator.

Mr. H. LINGARD (E.L.M.A. Lighting Service Bureau) showed a special piece of portable demonstration equipment designed originally for use by E.L.M.A. lecturers in connection with their educational work. It has, however, proved so popular and so effective in demonstrating the need for higher levels of illumination, that many Electricity Supply Undertakings have placed orders for similar equipment.

The apparatus is designed to allow the light-user to choose for himself the level of illumination he requires for seeing. Samples of various kinds, such as, a page from a timetable, white stitching on black cloth, black stitching on black cloth, etc., can be placed on the lower platform, and the observer can adjust the light falling on the test object between a range of 3 to 300 foot candles. Having selected an illumination which enables clear and comfortable vision, the test object is removed, and a light-meter below indicates the illumination chosen. It is also possible for samples of work to be placed in the cabinet when the lighting specialist is visiting a factory, and in the majority of cases experience has shown that the illumination level chosen is very much higher than normally available. A four-bladed shutter is employed to obtain the candle-power control. The light source employed is a 500-watt projector type lamp, and flashed opal glass is used between the lamp and the shutter, in order to ensure that the distribution of illumination from the source to the object is reasonably constant at all illumination levels.

(26) A Study Lamp.

Mr. LINGARD next remarked that although higher levels of illumination are required for comfortable seeing, it is realised that for economic reasons we cannot hope to achieve these much higher values immediately, nor can we expect drastic increases in illumination throughout interiors. One immediate step can be taken, however, to alleviate eyestrain, namely, to supplement the insufficient general lighting in rooms by local lighting of a higher intensity for reading, sewing, writing and other close work. In order to fulfil this requirement it was early realised that a portable lamp whose lighting performance was of a high standard was required and a Committee of the British Standards Institute is at present preparing a specification for a Study Lamp, both from the point of view of the illumination delivered, and the quality of that illumination.

In appearance the Study Lamp is an ordinary portable lamp, but it is being carefully designed by experts to give a vastly different lighting performance from that of the ordinary type of table standard. It is equipped with a 100-watt coiled-coil lamp in a reflector-diffuser surrounded by a decorative white-lined shade. The reflector directs approximately half the light upwards to the ceiling to provide bright surroundings and to eliminate all chance of contrast glare, while the remainder of the light is diffused downwards, providing a specified level of illumination on the table, needlework, or book. In performance all these lamps are the same, but they will be marketed in a multitude of different finishes to harmonise with any colour scheme.

(27) New Types of Adjustable Units.

Mr. H. C. COOPER (Mek-Elek Engineering, Ltd.) showed local lighting fittings of steel construction for industrial use. To obviate the well-known difficulty of taking cabtyre cable through the joints, the jaws are geared and linked together, giving an epicyclic motion through 360 degrees. The cable passes the pivot bolts in "S" form, so that when the joint is moved the lengthening of the cable round one pivot is always equal to the shortening round the other. The overall length of cable is thus constant, and there is no risk of kinking or of pull on the ter-

Types of "Mek-Elek" adjustable local units.

minals. The reflector is carried by a head of special design which relieves the lampholder of mechanical stress and protects it and the switch pushbar from accidental blows. The head swivels to throw the light sideways. The cable passes through the axis so that this motion cannot cause pull on the terminals, while a stop limits twisting to 330 degrees. The base is fitted with a connection box having a removable cover. This is particularly useful for machine mounting where a three core cabtyre cable can be taken from the supply and connected to the two core cabtyre cable in the fitting, the third core being brought out to the visible earthing screw. Alternative designs of base for bench, wall, or machine mounting are available, and reflectors can be supplied either for 60 watt lamps of main voltage or of a smaller size for 12 volt bus lamps.

(28) A Diffusing Corner Trough.

Mr. B. HAYTOR (Benjamin Electric, Ltd.) demonstrated a new form of enclosed diffusing trough unit, for use in locations where cornice lighting is desired, but the headroom is limited and no cornice is available. The metal back has two sides at right angles so that it will fit in the corner between the ceiling and walls. It follows that this unit, which takes two B.C. lamps up to 60 watts each, can also be installed in a vertical position in the corner between two walls, or can be built up into columns.

(29) An Under-Water Floodlight.

Mr. J. STUDHOLME (Benjamin Electric, Ltd.) showed a new form of portable unit introduced for use in swimming pools when built-in underwater floodlighting is impracticable. This new unit only requires that a small hole should be grouted in the wall of the bath for the fixing socket and can be installed with the water in the pool.

(30) New Designs in Silvered Glass Shop Window Reflectors.

Mr. W. R. STEVENS (General Electric Co., Ltd.) demonstrated a new range of silvered glass reflectors for shop-window, showcase, cornice lighting and the like, with the object of describing the part played by research in such work.

These reflectors are first designed on the drawing-board by a mixture of science and common sense in varying proportions. Usually, parabolic, elliptical, and spherical curves are used, and from these drawings the mould-maker produces a wooden pattern. Two such patterns were shown. After being checked the pattern is used to produce the final metal mould into which the reflectors are blown. This procedure ensures accurate reproduction of the original design.

Some figure is required on the surface of the reflectors to avoid filament images and considerable research had gone into the design of a flute which would just break up the images sufficiently to avoid striations without unduly spreading the distribution or producing losses in the glass by total internal reflection. The shallow flutes on the new reflectors were demonstrated.

Metal moulds and glass patterns of various types of fluting made in the course of the investigation were shown.

The Illuminating Engineering Society.

Informal Meeting on November 19

A new departure was made by the Illuminating Engineering Society on November 19, when an informal meeting, the first of its kind, was held at St. Ermin's Hotel (Westminster).

The proposition "That the User is the Ultimate Authority on Illumination," was proposed by Mr. A. Cunnington, Lighting Engineer to the Southern Railway, and was opposed by Mr. G. H. Wilson, of the G.E.C. Research Laboratory. The motion was further supported by Mr. R. R. Holmes and opposed by Mr. V. G. New. An entertaining discussion, in which about twenty members took part, followed. The motion, on being put to the vote, was carried by a rather narrow majority—42 to 36.

In the discussion, which was at times both amusing and instructive, it was evident that much depended on the interpretation of the proposal. In general, however, the right of the user to have a voice in the nature of the lighting provided was conceded!

It was generally agreed that the experiment had proved a most successful one. This was due in no small measure to the fortunate choice of the chairman, Mr. R. O. Ackerley, whose humorous and skilful management contributed greatly to the pleasure of the evening.

The Illuminating Engineering Society.

SPECIAL SECTION ON PHOTOMETRY AND ALLIED SUBJECTS.

Forthcoming Opening Meeting: January 28, 1936

Members will be interested to learn that the organisation of the above Section, the formation of which was approved at the Special Meeting on September 26, is now proceeding. The Organising Committee consists of: Mr. H. Buckley (Chairman), Mr. M. C. Bennett, Mr. F. C. Smith, Mr. E. Stroud, Dr. J. W. T. Walsh, and Mr. C. T. Winch, with Mr. K. F. Sawyer as Honorary Secretary. Arrangements have now been made for the Opening Meeting to take place at the Westminster Technical Institute (Vincent-square, London, S.W.1), at 6.30 p.m., on Tuesday, January 28, 1936. An introductory address dealing with certain outstanding problems in Photometry will be delivered by Dr. J. W. T. Walsh following the discussion of which suggestions for future meetings and visits, etc., will be welcome.

The Section has been established primarily for the benefit of members who are specially interested in Photometry and allied subjects. The Honorary Secretary (Mr. K. F. Sawyer, Gas Light and Coke Company, Watson House, Nine Elms-lane, London, S.W.8) will be glad to hear from all those who propose to attend the above meeting, who are interested in the work of the Section, and who would like to be kept informed of future meetings. We are sure that there are many enthusiastic photometric experts within the ranks of the Society who will respond to this invitation, which is also extended to any friends of members interested in the subject.

(No additional subscription will be demanded from members who desire to join the Section.)

Literature on Lighting*

(Abstracts of Recent Articles on Illumination and Photometry in the Technical Press)

(Continued from page 394, November, 1935.)

I.—RADIATION AND GENERAL PHYSICS.

322. The Mechanism of Light Emission.

R. W. Pohl. "Das Licht," p. 218, October, 1935.

A summary of a lecture given by Professor Pohl to the I.C.I., at its meeting in Berlin during July, 1935, dealing with the fundamentals of light emission produced by high temperatures, electric discharge through gases, fluorescence and phosphorescence. It is stated that the first recorded connection between electricity and light occurs in the experiments of Hauksbee in 1705 on electric discharges in evacuated tubes. S. E.

323. Theories of Vision.

Dr. F. W. Edridge-Green. Nature, Vol. 136, No. 3,445, November 9, 1935.

The visual purple theory of vision is explained and defended. This states that the cones are the only elements of the retina which perceive light, the rods being nerve elements regulating the supply of visual purple to the liquid surrounding the cones, the photo-chemical decomposition of this liquid stimulating the cones. R. G. H.

II.—PHOTOMETRY.

324. The Design of Precision Commercial Photoelectric Photometers.

G. T. Winch and C. F. Machin. G.E.C. Journal, VI., No. 4, pp. 205-212, November, 1935.

Recent progress in the design of precision photometers capable of working at commercial speeds is discussed. Both tungsten and discharge lamps are catered for in the equipment available. C. A M.

325. A Handy Calculator of Illumination.

Gas Times, November 16, 1935.

Contains an illustrated description of a useful calculator for working out illumination problems. The calculator has logarithmic scales of the various factors that have to be used in these problems. J. G. C.

326. Progress in Photoelectric Cells.

W. Kluge. Zeits f. Techn. Physik, 7, 17, pp. 184-193, July, 1935.

A comprehensive account of the present position and value of photoelectric cells of various types W. R. S.

327. Photoelectric Piles.

R. Jouaust. R.G.E., 38, 8, pp. 263-266, August 24, 1935.

An interesting historical survey of photoelectric cells with special reference to the work of Rigollot. W. R. S.

328. A New Selenium Sulphur Rectifier Photoelectric Cell.

G. P. Barnard. Proc., Phys. Soc., p. 477, May, 1935.

The paper describes a method of preparing a new Selenium Sulphur photoelectric cell of the rectifier type, and gives some details of the performance of such cells. A number of equations expressing the performance of such cells are given. S. E.

329. A Brightness Difference Threshold Meter for the Valuation of Glare from Light Sources.

B. H. Crawford and W. S. Stiles. J. Sci. Inst., 177, June, 1935.

An instrument for the evaluation of glare from light sources has been further developed and is now described in its final form. The method of use is described, and some results are given concerning the relation between the glare effect (equivalent background brightness), glare intensity, and glare angle. S. E.

330. Rapid Math. Methods for Trichromatic Colorimetry.

J. G. Holmes. Proc. Phys. Soc., 400, May, 1935.

Methods are suggested for reducing the labour involved in colorimetric transformations, with particular application to industrial applications. The calibration of an instrument by measurement of illuminant "B" is replaced by the measurement with the illuminant in actual use combined with a suitable stable factor. Simple methods of converting such readings to the I.C.I. basis are given. S. E.

331. Thermal Photometers.

R. Jouaust, R.G.E., 38, 13, pp. 419-422, September 28, 1935.

An account of the use of the thermal (total radiation) photometers with particular reference to heterochromatic photometry. W. R. S.

III.—SOURCES OF LIGHT.

332. A Spectrographic Examination of Arcs between Plane Soot Carbons, and its Connection with the Candle-power per Ampere of the Positive Crater.

J. T. Macgregor-Morris and *D. E. H. Jones.* Proc. Phys. Soc., p. 667, July, 1935.

Analyses of arcs between plane soot carbons of varying degrees of purity were made with a quartz spectrograph. The normal two electrode vertical arc and also a horizontal three electrode arc of Y form were used, parts of the flame only being photographed. Photographic enlargements of the ultra-violet parts of the spectra are given. S. E.

333. The Time Lag in the Attainment of Constant Luminous Output from Tungsten Filament Electric Lamps.

L. H. McDermott and *F. W. Cuckow.* J. Sci. Inst., p. 328, October, 1935.

A large number of tungsten filament lamps—both vacuum and gas-filled—were measured for change of luminous output over a period after being switched on, photo-electric methods of measurement being used. It was found that for high precision photometry, uniplanar vacuum lamps of 30, 75, and 100 watts should be burned for at least five minutes to attain constant candle powers to 0.1 per cent., while for a gas-filled projector lamp, two minutes' running was sufficient. S. E.

334. Super High-Pressure Mercury Lamp.

Anon. El. Times, 88, p. 479, October 17, 1935.

Gives particulars of a new lamp of the discharge type. By maintaining a very high pressure inside the lamp the luminous efficiency and brightness are greatly increased. A photograph and some technical data are given. W. R. S.

335. A Light Source for Research on Ultra-Violet Absorption Spectra.

H. Klumb and *R. Odenwald.* Zeits. f. Techn. Physik, 7, 17, pp. 200-202, July, 1935.

Describes a water-cooled lamp with interchangeable

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* We take this opportunity of acknowledging the services of the following Members of the Illuminating Engineering Society and others who have contributed items to the Lighting literature during the past year: Miss F. Barclay Smith, S. S. Beggs, F. J. C. Brookes, J. G. Clark, L. J. Collier, Dr. S. English, Dr. T. H. Harrison, R. G. Hopkinson, W. J. Liberty, C. A. Morton, W. R. Stevens, J. M. Waldram, G. H. Wilson.

electrodes of high-melting point material for use as a source of ultra-violet radiation. Photographs are given, including a 2 k.w. and a 10 k.w. size lamp. W. R. S.

336. The Design of Lighting Fittings for "Osira" Lamp.

S. S. Beggs and *G. H. Wilson.* G.E.C. Journal VI., No. 3, pp. 127-137, August, 1935.

A comprehensive record is made of the development of new industrial and street lighting fittings intended for use with high-pressure mercury discharge lamps. C. A. M.

337. Report of Joint Lighting Committee of the Institution of Gas Engineers (November, 1935).

Gas Times, November 9; Gas World, November 16; Gas Journal, November 13, 1935.

Refers to the work of the Committee in relation to the British Standard Specification for street lighting, the M.O.T. Committee on street lighting, etc. A special report on factors affecting the performance of street lamps suggests that 70 per cent. of the mean test-point rated illumination can be maintained in practice, and that no great loss in output will result from cleaning glassware once a fortnight instead of once a week. J. S. D.

338. Apparatus Used in Modern Railway Signalling and the Need for Further Developments.

A. E. Cattersall. J. Sci. Inst., p. 341, November, 1935.

A general account of the methods employed in modern railway signalling, dealing particularly with the electrical engineering side. The arrangement of the optical parts of "Light" signals and the possibility of using neon tubes are touched upon. S. E.

V.—APPLICATIONS OF LIGHT.

339. The Renaissance of Lighting.

Matthew Luckiesh. El. World, 105, p. 2558, October 26, 1935.

The author describes the development of the "Science of Seeing," which deals not only with the production or application of light, but its effect on human response and welfare. Light consciousness and the demand for suitable lighting grows with appreciation of the new science. Measurements on muscular tension and on the heart rate show the difference between the effects of adequate and minimum lighting. The lighting of the White House has been revised in accordance with these developments, and the new executive offices planned similarly. The need for education is stressed. S. S. B.

340. Illumination and Speed of Vision.

A. D. M. Atkinson. El. Times, 88, p. 125, July 4, 1935.

Includes results of tests made on a large number of observers at the E.L.M.A. Lighting Service Bureau. W. R. S.

341. Visibility: Its Measurement and Significance in Seeing.

Matthew Luckiesh and Frank K. Moss. Frank. Inst., J., 220, pp. 431-466, October, 1935.

The complex chain of factors and events resulting in visibility is discussed, and its significance and measurement in seeing are emphasised. Researches have established facts, laws, and relationships connecting barely seeing with easy seeing, making possible the interpretation of threshold measurements into practicable recommendations of footcandles and factors of safety in visibility. A visibility meter has been developed, giving rational scales of visibility and recommended intensities of illumination. Details of its theory, foundation, calibration, practical significance and use are presented. S. S. B.

342. Resolutions Passed at the I.I.C.

Lux. Pp. 117-125, October, 1935.

A complete summary of resolutions passed at the recent session of the International Commission on Illumination in Berlin. J. S. D.

343. Educational Highway Lighting.

Anon. El. World, 105, p. 2225, September 14, 1935.

The suggestion is put forward that heavy traffic routes should be equipped with modern lighting and a system of educational road-side signs to explain special features, and the value and importance of the lighting provided. Co-operation between State departments with this object in view is recommended. S. S. B.

344. Street Lighting.

Gas World, November 2; Gas Journal, October 30; Gas Times, November 7, 1935.

Contains preliminary reviews from the point of view of the gas industry of the interim report issued by the Departmental Committee of the Ministry of Transport on the street lighting problem. J. G. C.

345. Lighting of Foundries.

Anon. El. Times, 86, p. 462, October 10, 1935.

Abstract of paper read by R. W. Daniels, B.Sc. (H.M. Inspector of Factories), before the Inst. of British Foundrymen (London Branch). W. R. S.

346. The Use of High Pressure Mercury Discharge Lamps in Industrial Lighting.

R. O. Ackerley. G.E.C. Journal VI., No. 4, pp. 235-242, November, 1935.

The present-day use of high pressure mercury discharge lamps in industrial lighting installations is discussed in detail. Numerous photographs are given. C. A. M.

347. Lighting of the Brussels Exhibition.

P. Brune. Lux, pp. 113-116, October, 1935.

A descriptive article, containing illustrations of some of the chief illuminated buildings. A feature is the novel method of lighting the tramway station by means of floodlights and indirect devices. J. S. D.

348. Lights and Lighting at the San Diego Fair.

Anon. El. World, 105, pp. 2,438-9, October 12, 1935.

Some details of the supply, which is a semi-permanent installation, are given, together with several photographs and notes of lighting effects obtained. S. S. B.

349. Artistic French Lighting.

Anon. El. Rev., Vol. CXVII., No. 3,025, p. 671, November 15, 1935; B.I.P., pp. 200-205, November, 1935.

Describes, with photographs, some recent developments in lighting seen at the Salon de la Lumière. R. G. H.

350. The Artificial Lighting of Picture Galleries.

M. W. Peirce. G.E.C. Journal, VI., pp. 158-170, August, 1935.

The various problems associated with the artificial lighting of picture galleries are discussed. Numerous photographs of equipment and installations are given. C. A. M.

351. Floodlighting with Gas.

Gas Times, November 9 and 16; Gas Jour., November 6; Gas World, November 9 and 16, 1935.

Instances of floodlighting with gas, including Selby Abbey, a church at Minehead, and special displays in connection with the recent Centenary Celebrations at Dagenham are described and illustrated. J. G. C.

352. Illuminated Fountains.

Anon. El. Rev., Vol. CXVII., No. 3,023, p. 609, November 1, 1935.

Describes, with photographs, the methods used to illuminate a large fountain at Hull. Groups of projectors are used, giving various combinations of colours. Different combinations of water-effect, in conjunction with the colour scheme, are possible with the arrangement used. R. G. H.

353. Tubular Colour Lighting.

Anon. El. Times, 86, p. 499, October 17, 1935.

A brief account, with a photograph, of a three-colour lighting system employing tubular lamps. W. R. S.

354. Autumn Gala Lighting.

Anon. El. Times, 86, p. 443, October 10, 1935.

Describes decorative lighting at Chester (floodlit water-jets) and Blackpool (colour-changing lighting in a ballroom). Photographs are given. W. R. S.

355. Power Station Glazing.

Anon. Elect., 115, p. 463, October 18, 1935.

Successful glazing of two power-stations in Italy has been carried out with a new laminated glass, in which the interlayer is of glass silk threads. C. A. M.

Recent Patents

(Abstracts of recent Patents on Illumination & Photometry.)

No. 434,404. "Improvements in Electric Incandescent Lamps."

The General Electric Company, Limited, April 10, 1934 (Convention, Germany).

This specification relates to lamps having several filaments of which only one is in circuit when the lamp is new. A fuse is connected in series with the first filament and lamp terminals, and holds back a resilient member carrying a contact which, when the fuse blows, engages another contact to bring into operation another filament The filaments are preferably coiled coil. When a coiled coil filament breaks an arc usually starts, taking a current greater than normal so to blow the fuse.

No. 434,812. "Improvements in Miners' Safety Lamps or the like."

Hailwood, E. A., March 6, 1934.

According to this specification the construction of a safety lamp is such that the dome, and with it the inner glass and chimney if supported thereby, may be moved upwards and downwards in relation to the burner by means of a rod projecting outside the lamp, so that the height of the dome and flow of air under it to the burner may be adjusted for different conditions.

No. 434,919. "Improved Mercury Vapour Lamp, More Particularly for Projection Purposes."

N. V. Philips Gloeilampenfabrieken, February 5, 1934 (Convention, Germany).

According to this specification, a mercury vapour lamp, providing a small arc of great brilliancy for projection and like purposes, comprises one or more fixed incandescent electrodes and such quantity of mercury that its vapour is unsaturated under normal operating conditions, the power consumption per centimeter length of arc path exceeding one hundred watts. The arc path may be 0.5 to 2.0 cms. long, and the diameter of the approximately spherical bulb 30 mms. The discharge path is preferably vertical.

No. 435,053. "Improvement of Optical Apparatus for Lighthouses."

Stevenson, C. A., and Stevenson, D. A., March 20, 1934.

According to this specification, a group flashing arrangement comprises an illuminant and two or more reflectors or two or more illuminants and a reflector, the focal axis of the reflector or reflectors passing to the side of the illuminants or illuminant, so that the latter are ex-focal with respect to the reflectors. In an arrangement with one illuminant and several reflectors, one of the reflectors at least is set with its focal axis passing to one side in a horizontal plane of the centre of the illuminant, so that the angle between the beam from that reflector and that from another reflector is less than it would be otherwise.

No. 435,310. "Improvements in and Relating to Electric Discharge Lamps."

The British Thomson-Houston Company, Limited, and Maxted, R., February 19, 1934.

In order to permit a high-pressure arc discharge lamp to be utilised with the arc axis other than vertical, a magnetic device, such as a solenoid, energised in dependence upon the arc current, is arranged to produce a magnetic field to counteract the tendency of the discharge to be deviated from its proper path by convection currents within the lamp. The magnetic field is automatically adjusted to maintain the arc in a substantially axial position during starting and during normal operation of the lamp. To this end the magnetic device may comprise a pair of solenoid windings, separately energised, one providing a relatively constant field and the other providing a field varying with the discharge current. The two fields are in opposition to one another, so that, at starting, the resultant field is weaker than during normal running.

No. 435,375. "Improvements in or Relating to Illuminated Advertising and Other Signs."

Aristo Sign Company, Limited, and Kreslawsky, P., May 17, 1935.

According to this specification an illuminated advertising sign comprises a hollow stepped plinth or base, having windows or apertures in the steps and/or in the risers at the front, a light source mounted within, a paraboloidal reflector having a light source at its focal point mounted upon the base or plinth by means of a vertically adjustable strap or bracket and a disc or pane mounted within the open end of the reflector. The disc or pane is opaque, except for translucent areas exhibiting advertising matter. Advertising matter may also be exhibited upon the steps or risers or upon the front of the plinth. The disc or pane may be a mirror.

No. 435,632. "Improvements in Handles for Miners' Safety Lamps or the Like."

Hailwood, E. A., June 11, 1934.

According to this specification the handle of a safety lamp is carried from the lamp body by one or more moveable eyelets directly connected to a member adapted either to engage or to be free of locating or locking means provided upon the lamp, so that the handle may be turned and retained in a desired fixed position relative to the lamp. The handle may be slidable in the eyelets, and one end may be bent downwards and pointed so that it may be forced into a pit prop, for example, to support the lamp.

No. 435,663. "Improvements in Electric Lamps and Similar Devices."

The British Thomson-Houston Company, Limited, December 8, 1933 (Convention, U.S.A.).

This specification describes a construction of electric lamp or the like in which metal terminal members are united to the edges of pre-formed openings in a glass body or cap, rigid lead wires, supporting a filament or the like, are united to the terminal members, and the glass body or cap is sealed to the neck of a bulb.

No. 436,426. "Improvements in the Manufacture of Glass of High Permeability to Ultra Violet Rays."

Chemische Fabrik, Joh. A. Benckiser Ges, and Draisbach, F, February 21, 1934 (Convention, Germany).

According to this specification, glass for transmitting utra violet light is made by fusion of orthophosphates or meta-phosphates of beryllium with or without those of calcium magnesium or sodium.

Costs and Statistics of Street Lighting

by RONALD PARKER *(Registered Graduate of the London Association of Certified Accountants)*

(Delivered at the Twelfth Annual Meeting and Conference of the Association of Public Lighting Engineers, held in London during September 9th to 12th, 1935.)

It gives me much pleasure to be permitted to deliver this paper to-day. I am very conscious of, and grateful for, the honour conferred on me, a junior member, in being allowed to express my opinions upon this subject of costs—which, ever since street lighting came into being, has caused much heart-burning to our City Fathers, and has been the subject of much discussion amongst all who have been connected with the actual practice of street lighting.

Methods of Regarding Costs.

During the last decade or so the cost of street lighting has been viewed mainly from two angles, viz.:—

(i) The relative cost of lighting by different illuminants; and

(ii) The charge on the rates.

With regard to the former, the relation has been most often not really one of actual cost but of quoted prices—that is, a gas undertaking and an electricity undertaking have tendered for a contract to light the streets of a certain area, and their tenders have been compared Well, that may be the cost so far as the public body contracting for the work to be done is concerned, but more often than not such quoted prices bear little relation to the cost of doing the work. Moreover, such figures are of absolutely no value nationally, as they are not derived from a common basis.

As I shall illustrate later, the second viewpoint gives us very little better comparisons. It will be obvious that if accepted tenders are not comparable, lighting rates derived therefrom will be no more comparable. And even where a public body does its own street lighting other considerations render comparisons abortive.

Quite apart from the question of such comparisons, however, I maintain that the question of cost should not be viewed primarily from either of the angles stated. The object of street lighting is to give as much light on our streets as is necessary for the safety and convenience of the persons using them. That is the prime consideration; and the second consideration is how shall we do that most economically. In other words the question to be answered by every lighting engineer is " How much does it cost to provide a certain degree of visibility upon a given stretch of highway? "

The subject of street lighting is at last receiving some of the consideration which it deserves, and this has brought to light many misconceptions in regard to its cost. This is only natural. With few exceptions street lighting has been, and is, controlled by people who are not in a position to take an unbiassed view of the subject. They are concerned with other things and with them street lighting is only a " side line "; so that no matter how fair they may try to be they cannot help but be swayed by a consideration of the probable effect of a street lighting decision on their other interests.

Not only has this resulted in a biassed consideration of street lighting matters, but it has also led to a paucity of cost statistics of a national character. It would seem that some of those who are in a position to know the facts in particular areas are loth to reveal them wholly! I do not believe that this disinclination arises from unwillingness to obtain such data, but rather from the fear that these data may be used by others as a stick with which to beat them! This distrust of others has been a feature of all business in the past, but I am glad to see that it is at last being dispelled. May it be dispelled in our profession very quickly! We are out to give light. Let us do so in all things.

The M.O.T. Committee.

As is well known, in June, 1934, a Departmental Committee of the Ministry of Transport was set up to consider how a greater degree of uniformity in street lighting throughout the country could be achieved. That committee is still sitting, and, so far as I am aware, has not yet made any report. I feel, however, that there are certain obvious conclusions to which it must come when its deliberations are completed.

It is readily acknowledged by all that much lack of uniformity is brought about by the fact that most main traffic routes are subject to the control of numerous lighting authorities. This leads to chaos because each authority is not called upon to contribute proportionately to its use of the road. It seems necessary, therefore, that the incidence of the expense of lighting these main routes shall be radically altered. When one considers how this may be done equitably, one is bound to draw a parallel with the expense of the construction and upkeep of such highways, for after all, the lighting should be considered an integral part of each highway. In the case of general maintenance of classified roads, the Ministry of Transport contribute a certain proportion of the cost. In so doing they desire to know, of course, what the *true* cost is. Now I suggest that it is not unreasonable to expect the above-mentioned committee to come to the conclusion that an excellent way of obtaining a degree of uniformity in street lighting hitherto impossible, is for the Ministry of Transport to contribute towards the cost of maintaining the lighting service on classified roads. If that conclusion is drawn, and Parliament permits it to be put into practice, then the Ministry of Transport will want to know something about the cost of maintaining the lighting service on the roads to which contribution is made. If those directly concerned with street lighting are to be able to answer the question when it is put, they must know themselves what their service is really costing them. We may be certain that such rough costs as are usual at the present time will not satisfy the Ministry; something much more detailed and reliable will be required of us.

I feel that we should, therefore, direct a searchlight on to our expenditure, so that if, and when, the

time comes for us to receive assistance from the national purse, we may be found prepared. I am confident that such a course will never be regretted. It will quickly pay for itself in the little wastages

TABLE I.

Details of all the expenses which enter into the total cost of street lighting, showing :—

(a) The importance of each element, or group, of expenses in relation to the whole cost ; and

(b) The relative importance of the components of each element, or group.

Expense.	Amount of each Expense.	Percentage of Expense Group.	Amount of Expense Group.	Percentage of Total Cost.
1. WAGES :—	£	%	£	%
Lamp Attendants ...	13,296	64.6		
Lamp Maintenance, Transport, Works and Stores Administration, and Supervision ...	7,280	35.4		
			20,576	40.5
2. GAS & ELECTRICITY			19,426	38.3
3. MATERIALS :—				
Mantles and Electric Lamps	3,138	54.8		
Glass, Reflectors, Repair of Clock Controllers and Time Switches, sundry materials used in repair and replacement of existing lighting plant	2,100	36.6		
Washleathers, Cleaning Materials and Paint ...	374	6.5		
Repair and Renewal of Tools	75	1.3		
Repair and Renewal of Ladders	43	0.8		
			5,730	11.3
4. GENERAL WORKS EXPENSES :—				
Employer's Contributions to National Insurance and Subscription to Local Hospitals ...	584	36.0		
Transport Running Expenses...	407	25.1		
Uniform Clothing ...	316	19.5		
Repair of disturbed road surfaces	177	10.9		
Workmen's Compensation and Third Party Insurance	78	4.8		
Tramway Fares ...	60	3.7		
			1,622	3.2
5. ESTABLISHMENT EXPENSES :—				
Salaries & Superannuation	1,299	61.8		
Rates and Water ...	309	14.6		
Stationery and Advertising	151	7.2		
Petty Disbursements...	100	4.8		
Property Tax... ...	80	3.8		
Subscriptions to Technical Societies & Delegation Expenses ...	70	3.3		
Telephone Charges ...	50	2.4		
Motor Car Hire ...	25	1.2		
Fire Insurance ...	19	0.9		
			2,103	4.2
6. GRANTS TO EX-EMPLOYEES :—			1,291	2.5
Total Expenditure on Maintenance			£50,748	100%

it will reveal. Major economies in administration may be made by the use of sound common sense and very rough generalised statistics, but it needs a proper costing system to discover small economies. Costing should be to the administrator what the microscope is to the scientist, and if properly applied it will become indispensable.

Distribution of Expenditure.

The most important, most obvious, and yet most often overlooked, feature of costing is that it must include *every* expense. In other words, the sum of the products of the cost of each particular size of lamp and the number of that size in use, should be the total net expenditure on street lighting. It must include such things as hire of taxi for inspection work and the cost of attending this conference. If it does not it is not a true cost. Moreover, such overhead expenses as I have mentioned must be distributed equitably between those lamps. This cannot be done by simply dividing the total of such expense by the total number of units in use. It is not my intention here to describe a suitable costing system, but I do wish to emphasise that *every expense* must be taken in. It is a point which is so frequently overlooked.

In order to illustrate in a general way the relative importance of each element of cost, and of the importance of taking in all expenses, I have prepared Table I.

Examination of this will reveal that Groups 4, 5 and 6 comprise 16 different items of expenditure, almost every one small in itself, but which, when taken together, account for an expenditure of £5,016, a not insignificant figure.

In Group 1 it will be noticed less than two-thirds of the expenditure is on lamp attendants' wages, and in Group 3 very little more than half is spent on mantles and electric lamps.

In Group 4, the fact that 25 per cent. of the total for the group is in respect of transport may be surprising to some. It indicates what an important part mechanical transport is now taking in Lighting Department work. Moreover, the proportion is likely to increase.

Group 6 requires some explanation. Sheffield has no contributory superannuation scheme for its workpeople. To compensate for this deficiency the City makes a grant of a certain weekly sum to its retired employees, according to their service. As may be seen, it is an important item of expense.

In the preparation of the table expenditure on capital account was separated from revenue expenditure and was omitted from the table. This was done because Sheffield pays for the erection of all new lamps out of revenue. Actually, the figures quoted were those applying in the year ended March 31, 1935, and the expenditure on new plant in that year was £5,818. If the cost of erection of new lamps had been paid for with borrowed money, the cost of interest on the borrowed money and capital redemption would need to have been added to the revenue expenditure.

Table I., whilst illustrating in a general way the relative importance of the several elements of cost in street lighting, must not be taken as a guide to the relative importance of those elements when any particular size of unit is being studied. I have, therefore, prepared Table II. to illustrate the variation in importance of each element of cost in lamps of different sizes.

In this table it has been found convenient to treat gas and electric lamps separately, and I will deal with them in their order of appearance there.

One very noticeable feature of gas lamps is that labour is only of prime importance when the gas consumption is less than 7 cu. ft. per hour; thereafter gas is much more important. In order to make my figures comparable with those of most cities, I have made a calculation of the probable cost of interest and capital redemption at the rate applying in Sheffield, and this is an important part of the total cost of those examples taken.

The last remark applies equally well to electric lamps where, in the 60-watt size, interest and capital redemption is one-fifth of the total cost of the lamps. In all the examples taken current is the most important factor, but with high mounted units (from 300-watt inclusive in table) labour in the smaller sizes is a close second.

One trend common to both gas and electricity should be noted, and that is the diminution of the relative importance of interest and capital redemption with the increase in size of light source.

Proportion of Total Expenditure Formed by Cost of Gas and Electricity.

The indices in Table II. have been worked out on the charges for gas and electricity applying in Sheffield now. As these are lower than the average for the whole country, I have prepared a supplementary table (IIa.), showing the varying relative importance of gas and electricity for the examples taken in Table II. over a large range of prices. Should anyone wish to complete a series of indices for a particular price of gas or electricity, it will not be found difficult, since the other elements of cost are, on the whole, almost invariable.

To show what effect the price of current has on the other elements of cost, I give below extreme examples for both gas and electricity.

GAS.—Low-pressure gas. Inverted lantern containing ten medium mantles, arranged in circular form. Gas consumption 25 cu. ft. per hour. Units mounted 18 ft. high. Gas at 2s. 6d. per 1,000 cu. ft.

Gas	77.0
Labour	11.0
Materials	3.3
General Expenses	0.5
Establishment Expenses	0.7
Retiral Allowances	0.7
Interest on, and Redemption of, Capital	6.8
	100.0

TABLE II.

Showing the relative importance of each element of cost in relation to the total cost, for various sizes of lamps; based upon conditions applying in Sheffield at the present time.

1. Particulars of Lighting Fitting Used and Size of Light Source.	2. Labour.	3. Gas or Electricity.	4. Materials.	5. General Works Expenses.	6. Establishment Expenses.	7. Grants to Ex-Employees.	8. Interest & Capital Redemption.	9. Total Cost.
Square Lantern fitted with Directional Reflectors, 2 bijou mantles (3½ c.f.p.h.)	40.5	26.5	6.4	2.5	3.6	2.2	18.3	100.0
ditto 3 „ „ (5¼ c.f.p.h.)	36.1	34.1	6.2	2.2	3.2	1.9	16.3	100.0
ditto 4 „ „ (7 c.f.p.h.)	32.5	40.2	6.1	2.0	2.9	1.7	14.6	100.0
ditto 6 „ „ (10½ c.f.p.h.)	26.9	49.4	5.9	1.6	2.4	1.4	12.4	100.0
Inverted Lantern, 8 medium mantles in circular arrangement (20 c.f.p.h.)	23.7	53.1	6.1	1.2	1.3	1.5	13.1	100.0
ditto (10 medium mantles, 25 c.f.p.h.)	20.5	57.2	6.2	1.0	1.2	1.3	12.6	100.0
Open vitreous enamelled reflector, 60 watt pearl lamp	22.7	32.4	16.4	1.9	5.6	1.0	20.0	100.0
Mirror Directional Reflector, 100 watt pearl lamp...	18.3	40.5	16.3	1.6	4.2	0.9	18.2	100.0
Inverted Lantern fitted with dome refractor, 150 watt G.F. Clear Lamp	17.4	42.2	20.8	1.4	2.9	1.0	14.3	100.0
ditto 300 watt G.F. Clear Lamp	32.3	32.6	16.1	2.0	1.1	1.9	14.0	100.0
ditto 500 watt G.F. Clear Lamp	25.7	43.3	15.7	1.5	0.9	1.5	11.4	100.0
ditto 1,000 watt G.F. Clear Lamp	17.1	57.5	13.2	1.0	0.6	1.0	9.6	100.0

TABLE IIa.

Showing the effect of changes in the price of gas and electricity on the importance in relation to total cost of that element for the sizes of lighting units taken in Table II.

LOW PRESSURE GAS LIGHTING.

Gas Consumption per Unit. Cu. Ft. per Hr.	Percentage of Total Cost of Unit when Gas is Charged at:— 1/6 per 1,000 Cu. Ft.	2/- per 1,000 Cu. Ft.	2/6 per 1,000 Cu. Ft.
3½	34.85	41.68	47.15
5¼	43.63	50.82	56.35
7	50.21	57.37	62.70
10½	59.41	66.12	70.92
20	62.89	69.32	73.85
25	66.73	72.79	76.98

ELECTRIC LIGHTING.

Consumption of Energy per Point. Watts.	Percentage of Total Cost of Unit when Current is Charged at:— ½d. per K.W.H.	1d. per K.W.H.	1½d. per K.W.H.	2d. per K.W.H.
60	28.57	44.33	54.47	61.43
100	36.17	53.14	62.98	69.40
150	37.81	54.87	64.58	70.86
300	28.75	44.66	54.76	61.74
500	38.85	55.96	65.59	71.76
1,000	53.05	69.33	77.22	81.88

ELECTRICITY.—Lantern fitted with dome refractor, containing 1,000 watt G.F. lamp, mounted 25 ft. high. Electricity at 2d. per unit:

Electricity	81.9
Labour	7.3
Material	5.6
General expenses	0.4
Establishment expenses	0.3
Retiral allowances	0.4
Interest on, and redemption of capital	4.1
	100.0

Comparative Cost of Systems of Street Lighting.

Having dealt in Tables II. and IIa with cost of individual units, it is necessary now to deal with the cost of systems of street lighting. Below I give in Table III. details of the cost of typical installations, some utilising gas and some electricity, which were designed in accordance with the British Standard Specification for Street Lighting (No. 307, 1931). The table is based on the costs which apply in Sheffield now. It will be noted that no installations are given for classes "A" and "B." These classes have been termed "luxury lighting," and it is very unlikely that they will have any wide practical application for many years to come.

I may say that when the installations were designed, the primary object was to give a practical

TABLE III.

Examples taken from actual practice to illustrate the cost of maintaining street lighting installations in the various Classes laid down by the British Standard Specification for Street Lighting (No. 307, 1931).

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
					COST PER MILE.				COST PER 10,000 SQ. FT. OF CARRIAGEWAY.			
Width of Carriageway.	Mounting height of Sources.	Distance between Lamps.	Spacing-height Ratio.	Illumination at Test Point.	Electricity or Gas.	Other Maintenance Expenses.	Int. and Redemption of Capital.	Total.	Electricity or Gas.	Other Maintenance Expenses.	Int. and Redemption of Capital.	Total.
Ft.	Ft.	Ft.		F.C.	£	£	£	£	£ s. d.	£ s. d.	£ s. d.	£ s. d.
CLASS "C"												
36	25	125	5.0	0.5	393	231	38	662	20.13. 4	12. 2. 9	1.19.11	34.16. 0
CLASS "D"												
67	27½	112	4.1	0.35	438	258	45	741	12. 7.10	7. 5. 7	1. 5. 4	20.18. 9
40	25	112	4.5	0.3	219	237	27	483	10. 7. 7	11. 4. 4	1. 5.11	22.17.10
31	15	74	5.0	0.25	335	161	74	570	20.10. 1	9.16. 6	4.10. 0	34.16. 7
CLASS "E"												
34	25	120	4.8	0.12	205	221	25	451	11. 8. 0	12. 6. 4	1. 8. 5	25. 2. 9
37	25	93	3.7	0.1	264	285	33	582	13.10. 3	14.12. 1	1.13. 8	29.16. 0
CLASS "F"												
33	13½	80	5.9	0.066	126	151	48	325	7. 4.11	8.12. 8	2.15. 6	18.13. 1
29	13½	84	6.2	0.05	85	97	31	213	5.11. 2	6. 6.11	2. 0. 6	13.18. 7
37	25	120	4.8	0.08	205	221	25	451	10. 9. 5	11. 6. 3	1. 6. 1	23. 1. 9
CLASS "G"												
18	13½	95	7.0	0.033	39	59	24	122	4. 1. 4	6. 3. 9	2.10. 8	12.15. 9
33	13½	108	8.0	0.02	66	76	24	166	3.16. 0	4. 6. 9	1. 7. 8	9.10. 5
29	13½	78	5.8	0.034	114	106	33	253	7. 8.10	6.18. 2	2. 4. 0	16.11. 0
CLASS "H"												
16	11½	95	8.2	0.014	31	44	19	94	3.13. 5	5. 3. 1	2. 5. 9	11. 2. 3
16	13½	95	7.0	0.016	52	59	41	152	6. 2. 3	6.19. 3	4.18. 0	17.19. 6

TABLE IV.

Hypothetical examples of the cost of maintaining street lighting installations in the various classes laid down by the British Standard Specification for Street Lighting (No. 307, 1931), showing the upper and lower extremes of cost possible in all classes except "A" and "B." The calculations are based on the conditions applying in Sheffield now and include the cost of interest and capital redemption.

1.	2.	3.	4.	5.	6.	7.
Width of Carriageway.	Mounting Height of Sources.	Distance between Lamps.	Spacing Height Ratio.	Illumination at Test Point.	Cost Per Mile.	Cost Per 10,000 sq. ft. of Carriageway.
Feet.	Feet.	Feet.		F.c.	£.	£ s. d.
CLASS "C"						
50	25	105	4.2	0.87	1,593	60 6 10
36	25	135	5.4	0.6	550	28 18 8
CLASS "D"						
40	25	105	4.2	0.43	797	37 14 9
36	25	150	6.0	0.3	391	20 11 5
CLASS "E"						
36	25	125	5.0	0.18	451	23 14 6
30	25	170	6.8	0.13	278	17 10 6
CLASS "F"						
36	25	125	5.0	0.096	356	18 14 7
30	15	155	10.3	0.059	81	5 2 3
CLASS "G"						
25	15	80	5.3	0.04	131	9 18 6
25	15	165	11.0	0.026	61	4 12 5
CLASS "H"						
25	15	95	6.3	0.019	97	7 6 11
25	15	180	12.0	0.012	51	3 17 3

demonstration of what was at that time a new specification, but they illustrate exceedingly well the variation in total costs possible within any given class of the B.S.S. The installations taken were in no particular extreme cases, and greater variations are actually possible.

The wide diversity possible in cost between the upper and lower extremes of a given class of the B.S.S. is, of course, brought about by the relatively large variation permitted in the test-point illumination of that class. But the magnification of the lighting fitting used as reflected in the spacing of the units is a very important factor. Yet another important factor is that of the width of highway. A combination of all the extremes of these factors leads to a very wide divergence in cost, and I have attempted to show in Table IV. just how they may collectively vary the cost per mile of highway and per ten thousand square feet of carriageway.

In both Table III. and IV., the "Cost per Mile" and "Cost per 10,000 sq. ft." figures are based on conditions applying at the present time in Sheffield.

One of my intentions in collecting the data for Table III., and in drawing up Table IV., was to illustrate how misleading statements of cost can be, and I believe that the briefest examination of these tables will convince one that all such figures are of little value, in fact are definitely dangerous, unless accompanied by sufficient technical data to convey to the reader a good idea of the lighting effect of the installation.

Reduction of Lighting Hours.

It is convenient here to say something on the question of reduction of lighting at the times when the streets are almost empty of traffic. It is being urged in many quarters that the decreased visibility brought about by any such reduction leads to an increased possibility of accidents which is of far greater importance than the *relatively small saving* effected thereby. I have emphasised the words "relatively small saving" because they are the crux of much debate at the moment. The statistics I give are taken from actual practice in Sheffield with which I am intimately acquainted. I do not venture to express any opinion on the subject, but will leave the figures to speak for themselves. I will say, however, that I believe that in this matter each lighting installation must be considered individually.

The designer of the systems described wished to reduce the lighting to not less than one-half between midnight and dawn, when it was considered that the density of traffic was very low. In actual practice it was found impossible to reduce the lighting to one-half exactly, since street intersections and junctions and dangerous points had to be illuminated throughout the dark hours.

The first series of lighting systems included in my statistics cover streets which constitute the main routes into the city from the south, and from the east and north-east. They comprise:—

38 units with one 1,000-watt lamp in each.
23 units with one 750-watt lamp in each.
71 units with one 500-watt lamp in each.
2 units with two 500-watt lamps in each.
1 unit with two 300-watt lamps in each.

Almost all the units are mounted 25 ft. high, and overhang the traffic lanes in staggered formation, except in one stretch of very wide highway (300 yds.) where there are nine 1,000-watt lamps, and mounted on poles in the centre of the carriageway. The lanterns used are of various styles, but consist mainly of the usual type fitted with circular vitreous-enamelled reflectors, and either dome refractors, or dome mirror reflectors. The total length of highway covered by these installations is 4,920 yds. (2.8 miles).

Of the lamps enumerated, it has been possible to extinguish at midnight only the following:—

14 units with one 1,000-watt lamp in each.
10 units with one 750-watt lamp in each.
37 units with one 500-watt lamp in each.

The present cost of maintaining the lighting of these 2.8 miles of highway is £1,472.1s. 4d. per annum, including an estimated charge for interest on, and redemption of, capital. If all the lamps were allowed to continue burning until dawn the cost would be £1,741.14s. 10d per annum. Thus midnight reduction results in a saving of £269.13s. 6d. per annum, or 18.24 per cent.

My second illustration deals with a system of low-pressure gas lighting, which covers a distance of 1,010 yards, constituting the main entry into the city from the west. The installation consists of:—

18 units.—Inverted lanterns, ten medium mantles arranged in a circle, consumption 25 cu. ft. per hour, mounted 15 ft. high (except for four, which are mounted 20 ft. high);

28 units.—Inverted lanterns, eight medium mantles arranged in a circle, consumption 20 cu. ft. per hour, mounted 15 ft. high.

Of these, nine 10-light, and eight 8-light lamps are extinguished at midnight.

The present cost of this installation is £305.2s. 0d. per annum, including an estimated charge for interest on, and redemption of, capital. If midnight extinguishing had not been resorted to, the cost per annum would have been £347.4s. 10d. The saving brought about by midnight reduction is, then, £42.2s. 10d., or 12.14 per cent.

Since the saving brought about by midnight extinguishing is largely one of current and gas, it follows that the saving on large lighting units will be more, proportionately, than on small ones. Below, I give in Table V. the percentage of saving of midnight extinguishing for various sizes of lighting units. Again, these are based on Sheffield figures, and care must be taken to adjust them if comparison is to be made with others. Here also a variation in the cost of electricity or gas will alter the figure considerably.

If you wish to apply the data given in Table V., I would remind you that it applies to units only and not to systems, and, also, that the fact that lamps at

TABLE V.

Showing the saving brought about in the case of various sizes of lamps by allowing them to burn from dusk until midnight only. The calculations are based on the costs applying in Sheffield at the moment.

Type of Lighting Fitting in Use.	Consumption of Gas or Electricity.	Saving by Extinction at Midnight.
LOW PRESSURE GAS Lighting	Cu. Ft. per Hr.	
Square Lantern fitted with Directional Reflectors ...	3½	13.55%
ditto	5¼	17.93%
ditto	7	21.41%
ditto	10½	26.74%
Inverted Lantern, mantles arranged in a circle ...	20	30.85%
ditto.	25	33.35%
ELECTRIC Lighting	Watts.	
Open Vitreous Enamelled Reflector	60	24.40%
Mirror Directional Reflector	100	28.86%
Inverted Lantern fitted with Dome Refractor... ...	150	28.34%
ditto	300	28.35%
ditto	500	33.18%
ditto	1,000	38.68%

certain locations must be allowed to burn all night, will modify any proposal to apply the reduction to a definite proportion of the lamps in a system of lighting.

General Comparisons on Expenditure.

No paper on costing would be complete without reference to a body of statistics which has received much attention and is likely to receive still more. It is that which seeks to bring down the expenditure of various public authorities to a comparable basis, and comprises the figures of:—

(a) Net annual expenditure on street lighting;
(b) Rate levied in respect of public lighting;
(c) Cost per head of population; and
(d) Cost per candle-hour.

None of these is complete in itself, but the three latter ratios are attempts to provide a basis on which towns and cities of differing sizes may be compared.

There have been several attempts to achieve uniformity nationally in our street lighting, most notably that of our own Association's Editor in our Annual Report. Up to the present, however, not as much success has been achieved as one could desire. It is a most difficult task, and I hope that in due course we shall all realise the importance and utility of a reliable body of national street-lighting statistics and so make compilation much easier. Meanwhile, I would draw attention to some of the pitfalls to be avoided in the interpretation of such statistics as exist.

Total Annual Expenditure.

This figure is the starting point in the calculation of all the other ratios, and the comments I make below upon it will apply equally well to every ratio.

Some towns are already well built-up and others are in process of rapid expansion in the mileage of highways to be lighted. Expenditure on the erection of new lamps is of little value to us when we try to compare the street lighting expenditure of two towns, and it must be separated from the expenditure of an annually recurring nature (revenue expenditure).

One cannot say that having obtained revenue expenditure we have a strictly comparable figure. Many towns and cities light other places than streets, e.g., court yards, common stairs, and public clocks, and if we are to get a true figure for street lighting, expenditure on these things must be separated from the total also.

Even when we have obtained such a final figure comparison is not easy, for other factors must be taken into account. Firstly, and this is most important, what is the mileage of streets to be lit? It may be thought that if we are given this figure, and the total cost of street lighting, a good figure to compare would be an average cost per mile of street to be lit. This is not so. If a town has a relatively small mileage of highways it will follow, I think, that those highways are busy ones for the most part, and will have to be lit to a relatively high standard. All that we can do with the nett expenditure figure is, to my mind, to compare it with like figures, having in mind at the same time the other factors of mileage and business of streets. Probably the best plan would be to call for three figures of mileage, viz.:—

Total mileage of streets in the city.
Total mileage of streets classified by M.O.T.
Total mileage of streets unlighted.

A further important factor, entering into all comparative figures, is the cost of gas and electricity. Elsewhere it has been shown how important an element of cost this is, and I think it is obvious that a comparison of nett expenditure without this information is useless.

Still another factor which should be taken into account when comparison is made is the extent to which reduction of lighting intensity is resorted, either during summer or all the year round.

To summarise, I suggest that a figure of nett expenditure is of little value unless accompanied by:—

(a) A division of that expenditure between capital and revenue;

(b) A sub-division of revenue expenditure between street lighting and other work;

(c) A statement of the mileage of highways in the city or town, together with the mileage of important roads and unlighted roads;

(d) A statement of the cost of the illuminants used; and

(e) Particulars of any reduction of lighting hours.

The Street Lighting Rate.

This figure is very often quoted when comparison is being made between the cost of lighting in various places. Although it would appear at first glance to be a very good figure to compare, yet its value is illusory.

I think you will agree that while having some influence on the street lighting installed, the rateable value of the property adjoining a street has, in most cases, little or no relationship with the actual street lighting requirements of a street. Further, if comparison is made between the average rateable value per mile of street in different boroughs, a considerable variation is revealed. How, then, can a rate per pound of rateable value be of any service for comparing the relative degrees of street lighting in two or more boroughs?

Cost per Head of Population.

In order to be of real value this figure should be based on revenue expenditure for street lighting only, but unless capital and other revenue expenditure is fairly extensive the result on the final figure will not be very material from a practical standpoint. Because of this it is a good figure to use when making *rough* comparisons. Care must be taken, however, to ascertain that in a particular case there are not a great number of business and workpeople of the place who reside outside its boundaries; if there are, the resultant figure is likely to be abnormally high (e.g., think of the City of London). One other factor is of particular importance, the mileage of streets to be lit. In such a place as Glasgow or Edinburgh, where there are many flat dwellings, the density of population per mile of street is very high, and the cost per head correspondingly low.

If these considerations are kept in mind, cost per head of population is a fairly reliable guide.

Cost Per Candle-Hour.

As most of you are aware, in the request for statistical information circulated to members of our Association by our Hon. Editor last year, amongst other things was sought the above figure. Below I quote a paragraph which appeared in our Association's Annual Report for 1933-34 which has reference to that request:—

"Relatively few contributors gave the 'Cost per Candle-Hour (maintenance only),' and of these some gave what was really the 'Cost per Candle-Year,' some used the same expenditure as the sum of the figures in the 'Maintenance' columns for 'Gas' and 'Elec.,' some used a different figure which was apparently 'Total Expenditure' less 'New Schemes.' For these reasons and because the occurrence in some towns of more than one number of 'Burning Hours Per Annum,' introduced another complication in the calculation by the compiler of the cost for an average 'Candle-Hour,' this

column has been omitted. The range of the figures supplied, however, is from about 0.0003d. to about 0.003d."

That, I believe, puts my own criticisms of the figure into a nutshell, and I will deal with the points in the order raised.

As I have stated several times already, in order to be comparable calculations must be made from similar bases, i.e., they should be made from nett revenue expenditure on street lighting only.

The question of burning hours is the thing which renders the figure almost useless. Most towns have more than one lighting schedule in use, each giving a different total. In Sheffield we have three: lamps on main roads burning all night, lamps on main roads extinguished at midnight, and lamps on secondary traffic routes and residential roads. If we must have a figure of Cost per Candle-Hour, I suggest that the only way, when more than one schedule is in use, is to strike a true average of the total hours per lamp for the year by dividing the total lamp-hours by the total number of lamps in use, and then work out the required figure.

Personally, I think the cost per candle per year is a much more serviceable figure. Apart from other considerations the cost per candle-hour is so infinitesimally small that it has no meaning in our scale of normal values; it cannot be imagined.

Other statements of cost in general use are Cost per Mile and Cost per 10,000 sq. ft. of carriageway, but I feel that I have dealt sufficiently with them earlier in my paper. The latter is an endeavour to link up the road width with the length, and is only supplementary to the Cost per Mile figure.

Subject to the reservations I have made elsewhere, I believe this is an excellent way of describing the cost of lighting, particularly when linked up with the British Standard Specification for Street Lighting. Some may feel that such a linkage has been condemned by figures which I have given elsewhere. Ideally, of course, the cost figures should be linked to a statement of visibility, but this we cannot measure at present. We are compelled, then, to link it up with the next best thing, the British Standard Specification for Street Lighting.

Conclusions.

I will summarise my main conclusions:—

(1) Costing is an essential, and is likely to become very important.

(2) When cost figures are compiled, care should be taken to include all expenses.

(3) The relative importance of each element of cost is different for each size of lamp, and for every town or city.

(4) Quoted figures of cost should be accompanied by sufficient technical data as properly to describe the lighting referred to.

(5) When using total figures of street lighting expenditure, care must be taken to see that expenditure on capital and other matters than street lighting proper has been excluded.

(6) Of all the existing methods of stating cost, the calculation of Costs per Mile and per 10,000 sq. ft. of carriageway are best, particularly if linked up with the British Standard Specification for Street Lighting.

(7) Of the other common methods, "Cost per Head of Population" and "Cost per Candle-Year" may provide useful comparisons, providing due regard is paid to certain factors influencing them, but the lighting rate is of little value at all.

(8) Lighting engineers should build up a body of national statistics relating to street-lighting costs.

Finally, I would thank my Chief, Mr. J. F. Colquhoun, whose kindly help and advice at all times have enabled me to prepare this paper.

DISCUSSION

Mr. S. B. Langlands (Lighting Superintendent, Glasgow) said that many people had studied the rateable value method of assessment and, personally, he regarded it as inequitable. The day had gone by for that method of assessment. For instance, in Glasgow, there were cases of a shipping firm with an office paying a rental, say, of £200 a year, and, nearby, a large warehouse, the rental of which might be £5,000 a year. Yet the shipping company might be making thousands of pounds profit a year, whilst the warehouse made only £10! This illustrated the difficulty experienced by the author in trying to get a definite basis for lighting costs. In a paper which he himself had given recently he had pleaded for greater uniformity in charges for gas or electricity. He hoped that the National Gas Council and the corresponding national body for the electricity supply industry would take this matter in hand. With charges for gas, for example, varying between 2s. 6d. per thousand c. ft. and 11d., how was it possible to make any comparison as to the costs of street lighting?

Mr. A. G. Brown (London) remarked that street lighting was very much a question of economics—a subject which, at the moment, engineers were just beginning to study. The paper would be an exceedingly useful one for reference. One surprising fact revealed in Table I. was that the largest part of the cost of street lighting was the lamp attendant's wages. The relative importance of capital cost was emphasised in Table III. This actually appeared to be a minor matter, although many street-lighting Committees appeared to regard it as of prime importance. In the same way the saving in extinguishing lamps at midnight seemed relatively small—only about 25 per cent. In other words, extinguishing every other lamp meant a loss of half the light but only a saving of 25 per cent., or a little less.

Mr. W. Bache (Borough Electrical Engineer, Cheltenham) said that although the Tables in the paper gave a great deal of valuable information, the accuracy of that information depended very largely on the accuracy of Table I. If the method of allocation there adopted was correct, then it could be taken that the basis of the other Tables was likewise correct. It was a little difficult to understand why the author had separated the wages of lamp attendants from the lamp maintenance charges. In many cases they were so inter-mixed that a separate allocation seemed difficult. The lamp attendants in many undertakings did the repairs and ordinary maintenance as they went round. Further, the heading of "wages" should have been "labour cost," because "labour" comprised not only the amount of cash in the pay envelope at the end of the week, but also other expenses, which were really in the nature of labour charges. In this he included superannuation, National Health Insurance, and Unemployment Insurance—if the latter was paid where there was no superannuation. Incidentally, Mr. Bache expressed surprise that there was apparently no superannuation scheme for the workmen, but only for the salaried staff. The wages of transport were included under "wages" in another part of the Table; they should come under the heading of "Transport Expenses." Similarly, the inclusion of "Rates and

Water" under "Establishment Expenses" seemed a curious one. Was the public lighting undertaking separately assessed, because, if not, the incidence of rates should come on the cost of gas or electricity, and not as a separate item. An important omission from the Table was that there was no special compartment for improvements. The sum of over £5,000 a year was spent in improvements, and represented 12½ per cent. of the total cost of £50,000. If the author was trying to get out an estimate of the cost of lighting a street he would no doubt remove from his figures the amount spent in the previous year on improvements. This, in America, was called "betterment" and should appear as a separate figure, so that it could be assessed and correctly known.

Mr. T. A. G. MARGARY (Wolverhampton), referring first to the "G" and "H" classes of lighting mentioned in the paper, remarked that the height of the column was given as 13 ft. 6 in. He inquired whether the author had considered extending these columns by putting extension pieces on the existing columns and using reflector fittings to improve the lighting. He himself had done this and had gone to a height of 15 ft. 6 in. at a small additional cost. As to half-night lighting, how were the electric lamps in Sheffield controlled? In Wolverhampton, although half-night lighting had been considered on many occasions, the lamps were actually run all night. He had found that there would be little or no saving because the adoption of half-night lighting meant having a separate squad of men to do the switching off at midnight. On the other hand, if the ordinary street lighting staff were used for this, and also to carry out the maintenance during the day, some men at certain times of the year would be at work for twenty-four hours a day. In Wolverhampton the lamps were either individually switched or were switched in groups from certain strategic points about the town. We would like to know how the lamps were arranged in Sheffield, seeing that the author claimed a saving by switching off at 12.30.

Councillor J. WILLIAMS (Widnes) said it had been the practice in Widnes for forty years to charge the whole of the street lighting to the gas consumers. As chairman of the Gas Committee it had taken some persuasion to secure an allowance of 3d. in the £ from the rates for public lighting, but that had been done, and the gas consumers were carrying the remainder, which amounted to 7d. He had hoped that the author would have referred to marginal costs, i.e., the amount necessary to produce a certain amount of electricity or gas for street lighting beyond the quantity required for normal purposes. He did not regard it as a function of the Sheffield Electricity Department to make a profit out of the Street Lighting Department, and, therefore, a study of the marginal costs would reveal a new set of figures showing the actual cost to the town. This question of public lighting, continued Councillor Williams, had been intensified on account of the number of motor vehicles on the road. From that point of view motor licensing was all wrong. There should be two sets of licences, one for people who used their cars during the day and another for those who used their cars at night time, these latter licences being charged 50 per cent. extra.

Mr. H. E. PENNY (General Electric Company, Ltd.) called attention to the fact that the paper did not give figures with regard to the cost of replacing lamps. It was often impressed upon him by street lighting engineers how expensive it was to send a man out just to replace one lamp which had failed during service. Obviously, all lamps would eventually fail. The only way to avoid this heavy cost of replacing individual lamps was to replace lamps in batches after a pre-determined period. It was, however, sometimes urged that the cost of this method was prohibitive owing to expenditure on new lamps; he would like to know if this item was, in practice, compensated by the saving in labour costs.

Alderman E. T. FASHAM (Margate) remarked on the fallacy of speaking of street lighting in terms of cost per head of population. In the case of the extended Borough of Margate, with 42,000 population, the cost of street lighting per head was £4, but on the assessable value of £500,000 it was only 2 per cent. of the rates.

Councillor A. OATES (Sheffield), replying to the criticism that had been made as to the absence of a superannuation scheme in Sheffield for the workmen engaged on street lighting, explained that the ex gratia allowances made to the workmen, as stated in Table 1, which applied to those of fifteen years' service and over and amounted to 6d. per week per year, had acted detrimentally towards a contributory scheme. A contributory superannuation scheme had been put before the trade unions, which had taken plebiscites of their members, who, however, had not seen fit to accept it. In regard to other comments, he could assure the Conference that the rates were not poured out like water in Sheffield where, out of a 17s. rate, between 7s. and 8s. in the £ was for public assistance—notwithstanding the Government had taken over the able bodied under the Unemployment Insurance Act.

Councillor C. SMART (Rothwell, near Leeds), referring to the damage sometimes done to lamp-posts by motor vehicles, remarked that the maximum claim that could be made in such cases was £5. He wondered what action the author took with the insurance people to get that £5.

Mr. J. MANN (Glasgow), in a written contribution, said that for a given installation it was undoubtedly best that the cost should be arrived at on the basis of "cost per mile" or "cost per 10,000 sq. ft.," but, as the author had suggested, statements of cost could be misleading and dangerous, and this was very clearly shown in Tables III. and IV. These indicated that the costs of an installation were useless unless technical data were given, and this was the crux of the matter—because even approximate technical data were, if not impossible, extremely difficult to collect. The paper stated that the prime consideration of street lighting was to give as much light as possible and as was necessary for the safety of those using the streets. This meant increasing visibility, which should, therefore, be the basis of comparison. If, however the monochromatic nature of the electric discharge lamp increased visibility irrespective of mounting heights, spacing, wattages, etc., a costing comparison between such an installation and a gas-filled lamp installation was useless. Whilst recognising the advisability of being able to provide statements showing costs per mile or 10,000 sq. ft. to Ministry of Transport officials, and of their general interest to lighting engineers, Mr. Mann said he did not feel inclined to probe too deeply into them. Other statistics made a greater appeal to him, since they were more reliable and, therefore, comparable, such as the cost of a particular lighting unit, the effect of changes in the price of gas or electricity, etc. Whilst the necessity for careful costing could not be too strongly emphasised, the ultimate aim should not be lost sight of, and all that was not essential should be cut out to avoid confusion. In this connection he suggested that the percentages shown in column 2 of Table I., whilst interesting, tended to confuse and detract attention from column 4, which appeared to him to be the important one. He would prefer all the items of expense shown there to be expressed as percentages of the total expenditure. If this were

done, all argument as to which group a particular expense belonged to lost its importance.

Mr. R. PARKER, in his reply, agreed wholeheartedly with Mr. Langlands as to the unfairness of assessing property according to its rental value. He believed that quite a number of people agreed that a fairer way would be a local income tax.

As regards Mr. Brown's remarks, Table I. seemed to have been mis-read, because it showed that whereas lamp attendants' wages accounted for £13,000, gas and electricity accounted for over £19,000. The lamp attendants' wages, therefore did not form the most important item. Again, Table II. indicated that capital cost might amount to as much as 20 per cent. If that was not an important item of expenditure he did not know what was!

In reply to Mr. Bache, he said that Table I. had been prepared to show the relative importance of different wages expenditure. It had not been feasible to get out a better costs statement in the circumstances at Sheffield. In any event the whole of the wages were shown in the Table.

Sheffield had done as Mr. Williams had suggested, namely, added extension pieces to street lighting posts (in some cases 2 ft. and in others 1 ft. 6 ins.), in order to raise the point of light to 13 ft. 6 ins. To raise it still further to 15 ft. would require extension pieces of 4 ft. in length. This had been tried but was found to be insecure, and the author felt it would be preferable to have one complete post of the height required. Reflectors had been used in Sheffield for several years, and had definitely improved the lighting. As to midnight switching off, the arrangements in Sheffield were that so many lamps could be switched out at midnight by time-switches. This question of extinguishing certain lamps at midnight was one on which there was much controversy.

The question of marginal costs, mentioned by Mr. Williams, did not really concern the Sheffield Public Lighting Department, because it was not attached either to the gas or electricity undertaking. Whilst no doubt the view expressed by Mr. Williams was one which would be supported by public lighting engineers, it was not likely to be so universal among gas and electricity supply departments.

The relative cost of replacing lamps individually after they failed or in bulk at a time just previously to that when they might be expected to fail, had been studied in Sheffield. It had been definitely decided that no saving could be made by changing in bulk in the case of units up to heights of 15 ft.

On the question of recovery for damage done to lamp-posts, Mr. Parker said that in Sheffield the total damage so caused amounted to about £450 a year, but this was all recovered with the exception of about £25 incurred in certain cases in which the responsibility for the damage could not be definitely assigned.

Finally, Mr. Parker said he did not agree with Mr. Mann's views as regards visibility. Undoubtedly visibility was the important thing, but what they were prepared to pay for the "colour" was quite another question.

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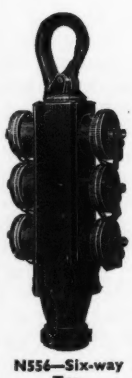
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Street Lighting in Germany with Special Reference to Berlin

By Dr. ING. J. ADOLPH *(Berlin Light and Power (Bewag) Company)*

(Delivered at the Twelfth Annual Meeting and Conference of the Association of Public Lighting Engineers, held in London during September 9th–12th, 1935.)

SUMMARY.

In surveying the fundamental problems of street lighting, attention is drawn to the need for internationally recognised standards of measurement and for satisfactory lighting regulations, and to the factors affecting the choice between gas and electricity for public lighting. After a general review of the nature and organisation of street lighting in Berlin, some details regarding recent improvements in the gas and electric system are described, particularly the use of metal-vapour lamps. Methods of remote control are mentioned, and the paper concludes with some remarks on main-road lighting and the lighting of junctions in the new German Trunk Roads.

(A) The Essential Features of the Street-Lighting Problem in Germany.

(1) General Problems.

It is well known, and the fact was again stressed at the year's meeting of the International Lighting Commission in Berlin, that no really satisfactory standard has yet been devised for judging the quality of a street-lighting system; likewise, there is no satisfactory method of measuring the factors affecting the quality of street-lighting. The terms "horizontal" and "vertical" illumination, "observation by contrast," "evenness," "brightness of the source of illumination," and their connection with "dazzle" are so diverse that a satisfactory and internationally recognised method of measurement can only be fixed with difficulty. In different countries commendable efforts are being made in this direction; so that one hopes that sufficient progress will be made in the next year or two to enable regulations, such as could find general recognition, to be drawn up for the guidance of street-lighting experts.

It is essential, however, to realise that in the end the most important factor in judging the effectiveness of street-lighting is the personal impression of the road-user. Clearly, the individual judgment of the quality by the layman plays a very important part; and we dare not neglect factors that can scarcely be expressed by a formula. The eye of the observer is here the best measuring instrument.

This applies particularly to the question whether electric-discharge lamps can be applied to street-lighting, and how widely they can be used. In this connection some interesting experiments made in the Schlossstrasse in Steglitz, one of Berlin's main thoroughfares, may be mentioned. This thoroughfare was fitted with mercury-vapour lighting as a specimen street for the International Lighting Commission. All drivers of vehicles were unanimously agreed that the illumination was extraordinarily good. But it was different with the pedestrians, who often objected to the colour, which was only slightly improved by a few filament lamps in shops and on advertising signs. It remains to be seen whether the voice of the public outweighs technical considerations in influencing the spread of gaseous-discharge lamps for the lighting of city streets.

The customary method of measuring illumination is still generally used in Germany, only the horizontal component of the light-ray being determined. The regulations lay down that this measurement shall be made at a height of one metre above the street—(one metre equals 1.09 yards); objective, as well as subjective, photometers may be used. The Deutsche Lichttechnische Gesellschaft, which forms the national committee of the International Lighting Commission, has compiled tables for the regulation of street-lighting intensities; besides giving the minimum requirements, the table includes "recommended" values.

Recommendations for the Lighting of Streets, Squares, etc., in Towns.

Traffic Density	Value of Illumination in Lux			
	Mean Values		Value in Worst Position	
	Min.	Recomd.	Min.	Recomd.
Weak	1	3	0.2	0.5
Medium	3	8	0.5	2
Heavy	8	15	2	4
Very heavy (in large cities)	15	30	4	8

The mean values given in the above table can be reduced to one-third of the value given outside normal traffic hours. To avoid "dazzle" it is recommended that between 60° and 90°—2 Stilb should not be exceeded.

(2) Gas and Electric Lighting.

The present position of gas and electric lighting does not enable us to draw conclusions about their relative merits. Historical development and conditions associated with local government have impressed their stamp on the methods of lighting employed. Even to-day, we in Germany have not yet reached the stage when we can base the choice between gas and electricity for a new project on purely technical and economic considerations. The choice lies rather with the body granting the concession, and that is generally the local authority, which not infrequently owns the gas-undertaking, while the electricity works are more often private companies, or companies only partially financed by the local authority. This state of affairs naturally has an influence on the choice of the illuminant—the tendency being for the local authority to incline towards the undertaking in which it is most interested.

The geographical position of projected lighting-systems is also important. In districts which are illuminated by gas, one would naturally not wish to construct islands of electric-lighting, as their maintenance costs might prove uneconomic owing to the amount of travelling time required for the staff. When planning entirely new areas, one would have to enquire whether a *single* kind of energy might not be sufficient, or whether both must be laid on.

At some future time we will assuredly experience a lively struggle between gas and electricity; in the end this will certainly prove an advantage by inducing the producers of both types of energy to strive after technical and economic improvement.

It is interesting to examine the relative proportions of gas and electricity for street lighting in some of the larger cities of Europe and Germany. Rome and Oslo are lit entirely by electricity. The Hague comes next with 99.7 per cent. of electric lights, then Zurich with 86 per cent., Stockholm 83 per cent., and so on. Only Brussels and Berlin exhibit really low figures, viz., 8.1 and 19.2 per cent. respectively, while Germany taken as a whole possesses 53.8 per cent. electric lighting. In Germany, too, there are some cities, such as Bremen, that are lit entirely by electricity; Stuttgart follows with 82.2 per cent.; Munich has 70 per cent., and Würzburg 68.8 per cent.

(B) Street Lighting in Berlin.

(1) Description of Berlin.

The city of Berlin covers an area of some 900 square kilometres, that is about 340 square miles: it is one of the largest cities of the world. Its greatest length from east to west is about 28 miles, and from north to south about 19 miles. This area may be subdivided as follows:

Built-up areas	19.1	per cent.
Streets, squares, etc.	9.0	„ „
Parks	2.2	„ „
Woodland	19.1	„ „
Lakes and waterways	5.9	„ „

The main traffic routes comprise a score of outlet roads radiating from the quarter round the cathedral and palace in the centre of the city. A secondary traffic-centre is situated near the Kaiser-William Memorial Church lying some four miles to the west. These main outlet-roads are joined by a number of circular routes threading through the city.

As the problem of street-lighting is strongly influenced by the fastest road-user, the power vehicle, it would be well at this stage to consider the Berlin traffic-returns. Thanks to the energetic support given to motoring by the government, the number of mechanically-propelled vehicles on the road has increased considerably in the last few years. While on December 31, 1932, only 114,000 mechanical vehicles were registered in Berlin, the figure had reached about 156,000 on July 1, 1935; that is an increase in two and a half years of over 35 per cent. There are still no signs of saturation; and it is to be supposed that the number will continue to rise steadily for the next few years.

The streets provided for this traffic are, with one or two exceptions in the inner town, wide and well-planned. The Friedrichstrasse, well known to most of Berlin's visitors, has a width from house to house at its narrowest point of about 14 yards, and a roadway 6½ yards wide; one of the widest streets, the Hasenheide, with a total width of over 70 yards, has a width of useful roadway reaching 25½ yards.

(2) The Essential Features of the Street-Lighting System.

Berlin possesses a total street surface, including pavements, of some 28 million square metres (nearly 34 million square yards). These are distributed among the different types of surface as follows:—

1. Large-stone paving	31.7	per cent.
2. Compressed and raw asphalt	25.0	„ „
3. Stone-paving	16.3	„ „
4. Small-stone pavements	7.8	„ „
5. Bitumen surface	6.8	„ „
The remainder, consisting of tarred-concrete, concrete, moulded-stone and wood-paving, accounts for	12.4	„ „
	100.0	per cent.

In main thoroughfares, the roadway is chiefly surfaced with asphalt or bitumen. As a result of the dense motor-traffic, the road surface in the main streets is highly polished, and special regard must be paid to the fact when solving the lighting problems. In Berlin we hold the opinion that it is desirable to suspend the lamps over the centre of the roadway, and not over the side-walk, believing that the fastest road-user—the motor-car—should have the most favourable lighting; besides which, lights hanging above the kerb are sometimes rendered impracticable by the foliage of the trees.

Aesthetic and architectural considerations must sometimes prevail over technical requirements. These suspended fittings, especially if they are awkwardly mounted, can sometimes spoil the appearance of the city. This consideration applies also to standards mounted on the kerb, which may also increase the danger to traffic.

When planning street-lighting schemes it is necessary to remember from the very beginning this need for even distribution of light. It is not admissible to have so-called "dark-zones" in the streets in which objects almost vanish from sight, as neither the horizontal nor vertical illumination provide the necessary contrast. For this reason a definite relation must be established between the height of the lamps and their distance apart. The most favourable conditions would be obtained in a roadway of 8-10 metres mean width with lamps 9 metres high, when the lamps were hung at intervals of 20-30 metres. These distances cannot often be realised because of constructional costs, but we try to keep the distance between lamps below 35 metres and to mount them as high as possible.

Though the problems of illumination are so various, when one remembers that, besides roads, there are many woods and parks in Berlin, one can assert with some justification that all the various problems of street lighting have to be dealt with. The construction of the new national trunk roads (Reichsautobahnen) and the need for lighting the entries have given rise to special problems that are dealt with in a special section at the end of the paper.

(3) Organisation of Street Lighting.

In Berlin we are still very far from the ideal conditions of street lighting that have been outlined. This is due in the first place to considerations of an economic nature. One should bear in mind that the consequences of the great war, the inflation, and the last economic crisis brought Berlin's finances into sore straits. Thus, in the year 1932 the street lighting was cut down considerably for financial reasons; and only now, after improvements in the economic conditions, can we reckon on an all-round increase in street lighting.

The Municipal authorities in Berlin, as the grantors of the concession, carry out the administration and determine the technical development. The German equivalent of the roadways department (the Tiefbauverwaltung) has a special street-lighting section with its own technical expert. This office grants the contracts to the gas and electricity authorities; the plans are worked out in detail by the companies concerned; the carrying out of the works being super-

vised by the officials of the administrative authorities of the twenty districts of Berlin.

Both the electricity and the gas companies maintain their own technical departments for street lighting; the electricity company also possesses a pnotometric laboratory for carrying out illumination research of all kinds.

(4) Gas and Electric Lighting in the Streets of Berlin.

In 1934 there were nearly 75,200 gas lamps and some 19,500 electric lamps in Berlin. Forty million cubic metres of gas and ten million kilowatt-hours of electricity were consumed in that year. As already explained, the historical development and the ownership of the gas and electricity companies have been mainly responsible for the present position.

The technical description given in the next section seeks to draw attention to some recent developments and peculiarities. Only a brief outline is given of the general arrangements, full details of which can be found in the pertinent literature.

(5) Street Lighting Equipment.

(a) *Gas*

As in most other cities, the fact that gas was the first illuminant in the field has had its effect on the development of street lighting in Berlin. The upright standard lamp, the first to be introduced, gave way to the inverted or hanging lamp that still predominates almost everywhere. There are in all 77,200 gas lamps in the city. The so-called Blohm lamp is to be recognised as a recent improvement. It is applied in two forms to the lighting of the Friedrichstrasse, one of Berlin's representative streets.

The modern lamps—in most cases they are not fitted with Blohm lanterns—may contain as many as nine burners; a small fraction of these (usually three) are left burning after the "half-night" lighting is switched off at midnight. High pressure gas-lamps are fitted in a number of main thoroughfares; the Königstrasse, a main shopping-street and import

Fig. 1. Gaslighting of Königstrasse Lamps mounted 5.7 m. high and 20 m. apart.

ant traffic route in central Berlin, is lit by high-pressure lamps with six mantles developing a total power of 2,000 candles. Curves showing the horizontal intensity of illumination produced are presented.

In some cases—in Hamburg for example—the gas department has recently introduced gas-lamps suspended over the centre of the street; these lamps may have as many as thirteen mantles, and are similarly provided with arrangements for half or complete extinction. The experience gained with these lamps is not yet sufficiently favourable to warrant their introduction on a large scale.

The gas-lamps in Berlin's side-streets are supplied with low-pressure gas, though most of the main thoroughfares have high-pressure gas-lighting. All the lamps are controlled individually, though not by hand; in both systems, low-pressure as well as high-pressure, the lamps are turned on by "gas-pressure

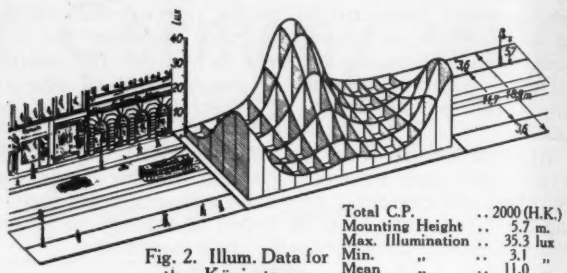

Fig. 2. Illum. Data for the Königstrasse (Gas-lamps)

Total C.P.	..	2000 (H.K.)
Mounting Height	..	5.7 m.
Max. Illumination	..	35.3 lux
Min. "	..	3.1 "
Mean "	..	11.0
Diversity Coefft.	..	11.4 : 1
Efficiency	..	37.6 %

switches," actuated by changes in the pressure in the gas mains.

A number of regulator stations for the high- and low-pressure gas networks, and switching stations for the electric lamps, are distributed across Berlin. These stations, and the central control room to which

Fig. 3. New Type of Gaslighting Equipment

they are connected, will be described in more detail later.

As these gas-pressure switches develop faults from time to time, patrols go along the streets each evening to light any lamps which remain unlit, and again in the morning to turn them out. In this way the service is ensured, though at considerable extra cost for personnel.

Departing from the generally accepted method of mounting vertical lamp standards on the kerb, the gas company has recently introduced an "outrigger-standard" with the lamp suspended over the roadway. The outrigger itself can be lowered on the oblique strut that supports it, and the lamp can be attended to from the ground with the aid of a small stepladder with two or three steps. From a technical point of view, this solution is a considerable step forward, as it enables the lamp to be suspended fairly far out over the roadway.

In recent times, gas-lamps have been developed in which reflectors direct the rays. The difficulties encountered in past years in trying to make the mirror-surface stand up to the high temperatures developed in gas-lamps can to-day be said to be overcome. Various firms now manufacture multi-burner gas reflector lights. These lamps are designed for oblique as well as for vertical illumination.

(b). *Electric Lighting.*

It might be said regarding the electric lighting in Berlin that all systems are represented. Besides the fittings for filament lamps that are used generally and are too well known to need description, arc-

lamps are widely used in Berlin. The 19,500 electric lamps in use in Berlin may be classified as follows:—

Arc Lamps	1,160
Filament Lamps	18,139
Metallic Vapour Lamps (sodium and mercury)	150
	19,449

Besides the 19,500 lamps in service, there are 3,900 lamps in position that are not used; these lamps were put out of service in 1931 as a result of the general economic crisis and they have not yet been reconnected.

The rating of the filament lamps ranges from 60 watts to 3,000 watts; but 200 and 300 watt lamps prevail in the more important streets (sometimes two of

Fig. 4. Typical Modern Electric Streetlighting Lanterns.

these are mounted in a single lantern). The size of the arc-lamps varies from 400 to 1,500 watt, while there are 275 and 550 watt mercury vapour-lamps and 70 watt sodium lamps in use.

Several interesting modern lanterns are illustrated (Fig. 4). The two upper ones are provided with glass cylinders to disperse the light, they produce good distribution and avoid dazzle. The lower ones are reflector lamps; the left-hand one has a double reflector and takes two filament lamps: the one on the right is an inclined reflector for oblique lighting. All these lanterns have been applied with good effect in recent street installations. In particular a 400 watt arc-lamp in which four pairs of carbons are connected in series across the 220 volt supply, giving 55 volts in each arc, has recently been introduced.

It is frequently suggested that the use of arc-lamps is a thing of the past. But the comparison of its characteristics with those of other types of lamp show that the arc-lamp is by no means outstripped. Comparison of performances of arc-lamps and filament lamps showed that though the working costs per watt for current service and maintenance were about ten per cent. greater than that of a filament lamp, the light efficiency was increased in the same degree and the light distribution curve was far more satisfactory. Thus we must admit that the arc-lamp is still a serious competitor with the other types of light for street-lighting; further, the burning life of the carbons has now been increased to 120 or even 150 hours. The Tauentzienstrasse, one of the main shopping and traffic thoroughfares in western Berlin, is lit entirely by arc-lamps. The street is divided down the centre by a strip of grass along which the trams run; the lamps are suspended in pairs, one over each half of the street, from horizontal wires stretching across the roadway.

The well-known Friedrichstrasse is also lit by arc-lamps; 500 watt arc-lamps are suspended over the

Fig. 5. Electric Lighting over Double Roadway with Trams (Tauentzienstrasse).

centre of the street at a height of 8½ metres and 30 metres apart. For comparison with the distribution curves for the gas-lighting in the Königstrasse figure 17 gives similar curves, based on the result of recent measurements, for electric-arc lighting in the Fried-

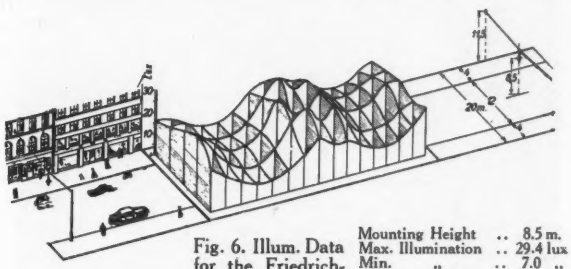

Fig. 6. Illum. Data for the Friedrichstrasse (Electric 500W. Arc Lamps)

Mounting Height	.. 8.5 m.
Max. Illumination	.. 29.4 lux
Min. ,,	.. 7.0 ,,
Mean ,,	.. 16.0 ,,
Diversity Coefft.	.. 4.2 : 1
Efficiency	.. 60.7 %

richstrasse. Similar 500 watt arc-lights suspended over the centre of the road are used to light the Charlottenburger Chaussee, a wide thoroughfare that runs through the Tiergarten, Berlin's central park, and connects east and west Berlin.

During the last two years the metal-vapour lamp has appeared in Berlin, as elsewhere, as a new competitor with the older sources of illumination. We are of the opinion that the mercury vapour lamp will provide a substantial improvement in the lighting of main thoroughfares; we believe, however, that in many cases the provision of additional light from filament lamps cannot be avoided, as the colour of the light would be a cause of complaint so long as there was any considerable pedestrian traffic along the streets in question. The sodium vapour lamp is, in our opinion, less suitable for lighting within towns, but it shows promise on country roads. This ques-

Fig. 7. Combined Lighting by Electric Filament and Discharge Lamps at Crossing (Heerstr.-Pichelsdorferstr.)

tion will be referred to again in connection with the lighting of arterial and trunk roads.

The Schlossstrasse, in Steglitz, a main outlet thoroughfare in south-west Berlin, was equipped with mercury vapour lamps for the International Illumination Congress in Berlin. It is a wide street divided down the middle by a strip of grass along which the tramway runs, making in effect two parallel one-way roads. Each of these was illuminated by 550 watt lamps suspended singly over the centre 8 metres above the roadway and 32 metres apart. The guaranteed life of these lamps is 2,000 hours. A crossing point in the Heerstrasse, the main Hamburg road, is lit by mixed lights; this is produced by 275 watt mercury vapour lamps in conjunction with a number of 200 watt filament lamps.

The lighting of circuses and other open places is generally planned so that few masts, but high ones, are required. The Alexander Platz, a busy square in the centre of Berlin, affords a good example of this system. Two or three tall masts support arc-lamps

Fig. 8. Electric Lighting of Alexander Platz.

at a height of 19.5 metres. There are three 750 watt lamps to each mast. Additional lighting is provided at points, such as tramway stops, where traffic is at its densest; this is achieved by suspending filament lamps overhead.

It is of considerable interest to compare the consumption of various types of electric lamps and the amounts of light they each produce per watt. The light-rating (lumens per watt) of filament lamps increases steadily as the rating rises from the lowest values to 1,500 watts. The arc-lamps, despite the fact that their light-rating is independent of size, are rather more efficient. Mercury vapour lamps, reckoned purely on light output, are still more effective, the larger units being the best. The sodium lamp is best of all, and the light-rating increases rapidly with size.

Some two-thirds of the electric street lamps in Berlin are controlled automatically, and their condition is indicated automatically in the switch-houses. The remaining third are connected to time-switches, each street being controlled as a unit. Besides the gas company's regulator stations, referred to previously, there are four remote-switching stations belonging to the electric company. A network of pilot cables radiates from these, so that even the most distant sections are under constant control. Should a fault occur, even at a remote point, the fault sets up a corresponding signal in the switching-station.

The remote control operates in the following manner. Each section of street lighting is controlled and fed from an automatic switch-kiosk. This kiosk receives its supply direct from the power mains, the switches are each controlled by a single pilot from the control station (1.5mm.^{2} cross-section). If the section is in service and is to be switched off, a phase of the power network in the central station is momentarily connected to another phase in the kiosk by means of a contactor and one core of the pilot cable: the circuit then made includes the trip-coil of the required switch in the kiosk, and then the selected

Fig. 9. Light Control House for the City of Berlin.

switch opens and its respective circuit is cut out. The opening of the switch sets up the necessary connections for closing it again when required; the closing operation is carried out in a similar manner by momentarily connecting the closing coil across another pair of phases.

But this does not complete the task of the pilot-cable network. The individual circuits leading to the lamps are fitted with pilot-relays carrying the power current. If a lamp fails this current is decreased and the relay opens. This breaks a connection between the earth in the central station through a galvanoscope, the pilot cable, and the relay to a phase of the supply in the kiosk. The breaking of this circuit leaves one of the galvanoscope coils without voltage, and by means of an auxiliary contact the fault is signalled in the central station by the lighting of a small lamp.

By utilising a flexible three-phase supply, separate circuits are arranged for lamps that burn all night, and lamps that go out at midnight. The kiosks themselves are similar in appearance and size to the London tramway kiosks.

Beside the method of remote control by pilot wires there is a system in operation in Germany, e.g., in Potsdam, that is operated by high-frequency currents injected into the power network. This is the (so-called) Tel-Energ system. Special frequency relays control the switches in the lighting kiosks; these relays respond to a single frequency only. To operate the relays high-frequency power is injected into the system by a variable-frequency generator in conjunction with a filter circuit. This switching system has also been applied with success to the control of the variable-tariff meters (double-tariff meters, triple-tariff meters, etc.) and other remote-controlled switches in the network. A somewhat similar installation is in operation in Paris.

(c) *Common Control of Gas and Electric Lamps by Lighting Control-Room.*

To escape from the disadvantages of the rigid lighting-up time of the calendar, by which the switching times used formerly to be fixed, the Berlin authorities, assisted by the gas and electricity companies set up a common lighting control room that was occupied towards dawn and dusk each day. It is a small octagonal tower capped by an observation room. The existing intensity of daylight is observed by means of a photometer, and when the intensity reaches a predetermined value, regardless of the lighting-up time given in the calendar, the necessary order is given to the individual stations of the gas and electricity networks. The lamps are lit in the

evening when the intensity falls to 6 Lux and are extinguished in the morning as soon as 0.5 Lux are recorded.

There are some thirty control stations in communication with the lighting control-room; these comprise four electric switching stations belonging to the Berlin Electric Co. (Bewag), and one to the South-Western Electric Co., that supplies independently three of the twenty Berlin areas, viz., Schöneberg, Wilmersdorf, and Schmargendorf, and twenty-five regulator stations belonging to the gas company.

In this way we attempt to compensate for the incalculable variations in the light intensity caused by the prevailing weather conditions.

More recently experiments have been made with a view to changing over from the subjective determination of the local light intensity to a more objective method employing light relays. Tests carried out up to the present certainly show that such relays (twilight switches) are good, but they do not yet work with sufficient accuracy for our purpose. It is, however, our intention to equip with such units all those kiosks that are not connected to the central stations, thus freeing them also from the rigid lighting-up time of the calendar and the frequent necessity of resetting the time-switches.

(C) Traffic and Other Special Lighting.

Besides street-lighting itself, there are a number of other duties which are assigned to this department of the Berlin Electricity Co. (Bewag). In this category are the supply and control of:—

470 Post-office Telephone Kiosks.
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35 Signal Lights on rivers and canals.
135 Light Pillars on traffic islands.
11 Sunken Lights at road junctions.
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and various other installations serving transport generally.

Among the modern traffic lights in Berlin are traffic-operated lights, similar to those used in London; another modern light works like a clock, and enables the driver to estimate how soon the lights are going to change. Illuminated arrows have proved useful in directing traffic into one-way routes, etc., and illuminated signs direct passengers towards the Underground Railway stations. Illuminated pillars at tram stops show the running time of the trams passing the point, part of the cost of these pillars being defrayed by the advertisements they carry.

Another task falling to the Lighting Department is the flood-lighting of public buildings, etc. Notable

Fig. 10. Illumination of the Brandenburger Tor.

examples of this class of work are the flooding of the Memorial of Honour in Unter den Linden, where considerable restraint combined with a cheerful effect were required. The Brandenburger Tor, at the entrance to the Linden, affords an example of successful flood-lighting from both sides. Lastly, the illuminations of one of the Bewag's smaller power-stations shows how use can be made of strong internal lighting for throwing into prominence the long vertical windows. Mercury vapour lamps combined wih filament lamps were used for flooding the outside of the building. There is always a good deal of interesting flood-lighting to be seen in Berlin.

(D) Special Problems.

In recent years a number of new lighting problems have unrolled themselves in Germany, especially in connection with the Reichsautobahnen, the National Trunk Roads, now under construction, that in a few years will traverse the country from east to west, and north to south. Because of their great length, there is no intention that these roads should be illu-

Fig. 11. Dallgow-Döberitz Road lighted by Sodium Electric Discharge Lamps, mounted 10 m. high and 20 m. apart.

Fig. 12. Lighting of Köln-Bonn motor highway with 70-watt Sodium Electric Discharge Lamps.

Fig. 13. Another view of the Motor Highway illustrated in Fig. 12.

minated throughout—the installation cost would be too great. But it is proposed that general illumination be provided in districts in which these roads traverse built-up areas, and at those points where there are junctions between the trunk roads and the ordinary main roads of the country.

The Government has not yet reached a final decision regarding the method of illumination to be adopted; but trial installations of various types have been constructed with that end in view. It appears that sodium-vapour lamps are particularly suited to this type of lighting. A trial installation of sodium lamps has been erected on the main Hamburg road at Berlin. Sodium-vapour lamps, rated at 70 watt, are suspended over the centre of the roadway at a height of 10 metres, and at 20 metre intervals. The constructional details exhibit a number of innovations. The ordinary method of suspending the lamps from horizontal wires stretched across the road between two posts has been rejected; pairs of masts have been set up at intervals of 100 metres. These support a horizontal wire running longitudinally down the road; the lamps are attached to this wire. A section of the main Garmisch road, near Munich, has been equipped in a similar manner.

One of the first completed sections of the new trunk roads—the road from Cologne to Bonn—is lit by sodium lamps, similarly arranged. Here the quality and the evenness of the illumination is extraordinarily good.

DISCUSSION.

Mr. C. HARPER (Barking) complimented Dr. Adolph on his address and remarked that, whilst the world might be divided politically into nations, it was definitely international in the realm of science. In that realm they were all brothers.

Mr. H. G. PALMER (Director, Tottenham and District Gas Company) recalled that his great-grandfather had travelled to Berlin on behalf of the Imperial Continental Gas Association many years ago in order to negotiate the contract for the supply of gas in Berlin. It was, therefore, of interest to observe that gas lighting was still serving to light the streets of that city. He was struck by the extraordinary height —20 metres, i.e., approximately 60 ft.—of certain posts in Berlin. Some notes on the candle-power used on these very high posts would be of interest.

Mr. F. C. SMITH (Research Laboratories, Gas Light and Coke Company), as one of the deputation that had recently visited Berlin in connection with the I.I.C. Conference, welcomed this opportunity of thanking their German hosts and friends for the wonderful hospitality which they had received. He recalled especially the inspection of the lighting of the streets in Berlin, which were often very wide and separated by a grass verge. He noticed many interesting gas lighting installations in Berlin and elsewhere, and recalled one type of unit, adopted in Cologne, in which a mirror glass reflector was used in conjunction with a lantern having an obscured bottom portion. He also recalled being driven over the route mentioned by the author as being lighted by mercury discharge lamps; this was certainly a wonderful installation.

Mr. E. C. LENNOX (Newcastle-on-Tyne) asked for information on the steps taken in Germany in 1932 to cut down street lighting costs. It would be interesting to know the number, size, and candle-power of lamps dealt with and the effect of the diminution on road safety. He was also much interested in the system of control by injecting high frequency currents into the power network, and would like to know how far this had proved successful. Finally, Mr. Lennox expressed his interest in the control of the street lighting from the "control house," and inquired how far the lighting-up times determined by observation agreed with those previously calculated and based upon sun-set times.

Professor G. VAN DE WERFHORST (Holland) expressed the pleasure felt by himself and his Dutch colleagues in attending the Conference and seeing for themselves actual conditions of street lighting in England, as compared with the Continent. He was specially interested to observe that attention was now being concentrated not only on theoretical brightness, but actual visible brightness. There was often a big difference between the two. The main object should be to obtain sufficient contrast, and installations should be planned with this in view.

Mr. G. H. WILSON (G.E.C. Research Laboratories) said that the paper was specially interesting for the differences in technique on the Continent and in this country which it revealed. During the excellent tour in Berlin, and the inspection of lighting in Cologne and some other cities, he had formed the impression that, under given conditions, roads in Germany seemed to be bathed in a sort of soft glow, whereas in this country a brighter road surface, and naturally rather more glare was usual, because the light-sources were more exposed. Personally, he preferred the latter effect, but there seemed need for the application of some form of visibility test in order to determine which was really the better. It would be valuable if we could introduce a little of Continental practice into this country in order to facilitate such comparisons. The arc lamps mentioned in the paper seemed to be different from the opal ring non-glare type of unit so common in Germany. He would like to hear the lecturer's view of the relative merits of the two types. Finally, he would be grateful if he could have the times of switching on each evening in Berlin, in order to make comparisons with his own lighting-up table. It was stated in the paper that the lights were switched on at night when the illumination was 6 lux, but were switched off in the morning when it was only 0.5 lux. It would be interesting to know the reason for this difference between practice at morning and evening.

Mr. E. STROUD (London) recalled an experience when inspecting the Dallgow-Döberitz road, near Berlin, which was lighted by sodium lamps. As regards the production of uniform visibility he could not recall a better installation, as it then appeared. Some measurements of surface brightness were made. Whilst the surface was dry there did not seem to be a square yard of road which was not fully visible. The road was somewhat narrow and faced with granite setts, and the lights were centrally suspended. Presently, however, heavy rain began to fall. When this occurred and the surface of the roadway became thoroughly wet the area of brightness seemed to shrink, until there was only a ribbon of brightness due to the reflection of units running along the centre of the roadway. In making for their car they were nearly run down by a cyclist who had temporarily disappeared in a dark patch. He mentioned this incident to show how greatly surface brightness conditions were dependent on the weather, and how conditions that were admirable for a dry road might become a source of danger when the surface was wet.

Mr. F. X. ALGAR (Irish Free State Electricity Board) expressed appreciation of the paper and of the courtesies which he had received as a member of the delegation attending the recent conference in Germany. He had been much interested in the arrangement of the light-control house in Berlin, and in the general use of centrally suspended traffic-control signals. He had wondered a little whether such signals might not cause drivers of motor vehicles to take their eyes off the road at critical moments and thus give rise to occasional accidents.

Mr. J. ECK (London) commented on the fact that 19.1 per cent. of the Berlin area was woodland. He

wondered whether there was any special method of lighting adopted for these wooded areas, which were so charming in the daytime. Although the amount of street lighting by arc lamps in Berlin was only a little over 6 per cent., the proportion, in terms of candle-power, would be more like 20 per cent. He recalled that arc lighting was still doing good service in the City of London, and there were quite a large number of arc lamps in Dublin. He felt that it had been a little unfortunate that there had been no strong body to serve the arc lamp, in the same way as the electric incandescent lamp—with the result that the manufacture of carbons had been almost discontinued, and the arc lamp had been allowed almost to die out. Those who had seen the wonderful lighting of the Brandenburger Thor with arc lamps were no doubt impressed. Although some degree of glare might arise with such powerful lamps at moderate levels, excellent results were obtained with lamps at the height of twenty metres, and he confessed that he would like to see a similar installation in Trafalgar-square.

Mr. J. P. BLACKMORE (Bombay) pointed out that what might be good practice in Berlin or London might be quite impracticable in some other parts of the world. Much depended on the habits of the people, the materials available for road-making, the number of daylight hours, etc. In India there was a very rapid sunset. Most of the native population enjoyed their games early in the morning, and went to bed early at night. There was no real night life, and streets were often comparatively empty after 9 p.m. These conditions naturally influenced street-lighting practice in India. In that country, where so many different castes and creeds existed and preservation of order was of prime importance, it was often expedient for the lighting of subsidiary roads to be as good as that adopted in main thoroughfares.

Mr. H. ALLPRESS (Birmingham) remarked that experiments had been made in this country with Continental systems, most of which seemed to be based on the use of fittings having a definite cut-off and spaced at relatively small intervals. He had formed the impression that they did not appeal to English mentality. He recalled an example of sodium lighting on a road passing from Holland into Germany, where the cut-off was about forty-five degrees to fifty degrees. Beyond that angle little or no light escaped. Yet it had been pointed out in Mr. Smith's paper that the reflection of light falling on the roadway was much greater and better for light incident at eighty degrees to ninety degrees—so that there was a double disability, the fact of little light being projected downwards at the high angles, and the further fact that the reflection effect in these circumstances was poor. He thought, however, that we could learn something from the relatively close spacing adopted abroad which might well be advantageous with units of the refractor type, so mounted that their beams overlapped.

Dr. J. ADOLPH, briefly replying to the discussion, explained that the height of 60 feet for certain posts, which carried 1,500- or 3,000-watt lamps, was adopted only in wide open spaces, not for ordinary street lighting. In Germany they had little experience of fog! The "Tel Energ" system of control described in his paper was being used in Potsdam to control street lighting, and was adopted elsewhere for other purposes. The system, however, required A.C. The parks within the city were lighted and had main roads and traffic running through them, but some of the woodland areas in the vicinity of Berlin were open country, and were not lighted at night. In conclusion Dr. Adolph expressed his appreciation of the reception he had received in London. He added that any engineer desiring full information need only write to him—or better still, visit Berlin so that they could see things on the spot.

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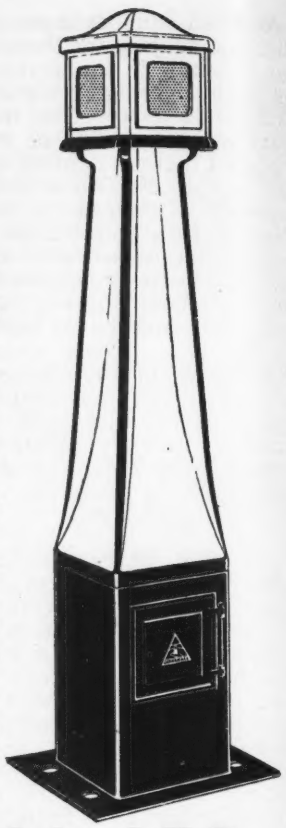

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An important decision has been taken by the Metropolitan Borough of Lambeth, which is adopting lighting by means of Osira electric discharge lamps throughout practically the whole of the area bounded by Vauxhall and Westminster Bridges on the Thames front, and Elephant and Castle and Kennington Oval on the South side. The lamps will be installed in prismatic lanterns, on tall columns with an average height of 25 ft. above the roadway, 400-watt lamps are already in operation along the Lambeth Palace-road. In the lesser thoroughfares 250-watt lamps will be used. The contract was secured by the South London Electric Light and Power Co., Ltd., under the direction of Mr. W. J. Allbright. Osira lamps are, of course, a product of the General Electric Co., Ltd.

Street Lighting with Gas

We understand that the Falmouth Borough Council and the Chertsey U.D.C. have entered into contracts with the local gas undertakings for periods of five years and ten years respectively. In Edmonton an offer by the Tottenham and District Gas Company for the improved lighting of Edmonton for a period of seven years, with the option of terminating at the fifth year, has been accepted. This contract affects about 1,850 gas lamps. The City of Nottingham has obtained a twenty-year contract for the improved lighting of 1,283 yards of Mansfield-road, one of the main roads leading north of the city. The scheme involves the replacement of a number of three-light square lanterns by six-light lamps with directional reflectors.

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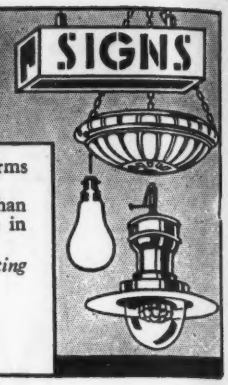

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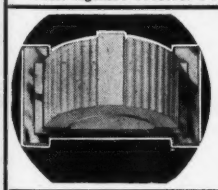

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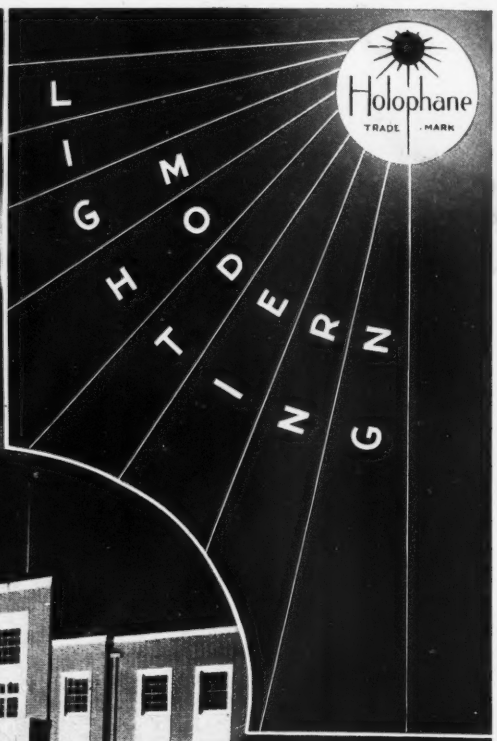

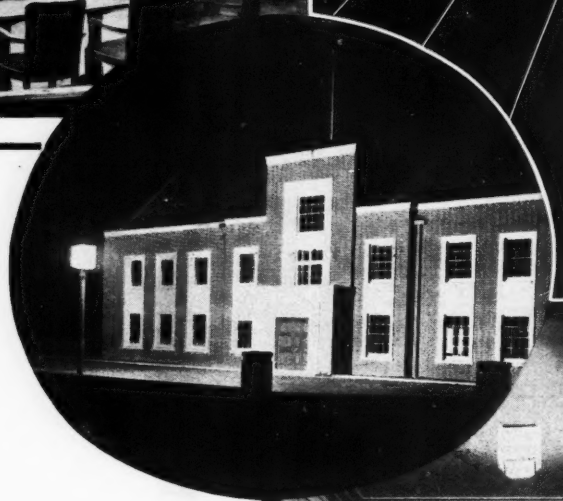

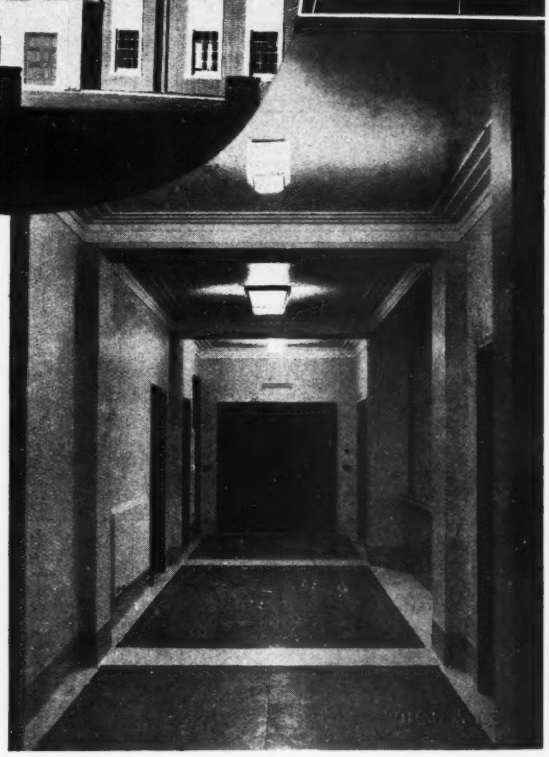

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Top photo shows the Council Chamber lighted by HOLOPHANE BUILT-IN PANEL FITTINGS equipped with interior Prismatic Focussing Type Reflectors.

Centre photo shows the exterior of the building lighted by a single Holophane HF-1000 Wide Angle Floodlight.

Bottom photo shows a corridor lighted by Holophane Close Ceiling Panel Fittings.

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